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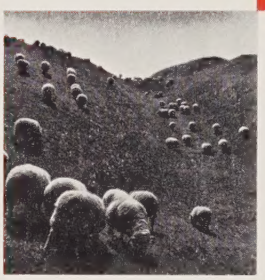

On the cover is shown a flock of Dorset Horn ewes grazing in their native county. This breed, of which both sexes are horned, is well known for its autumn lamb production.

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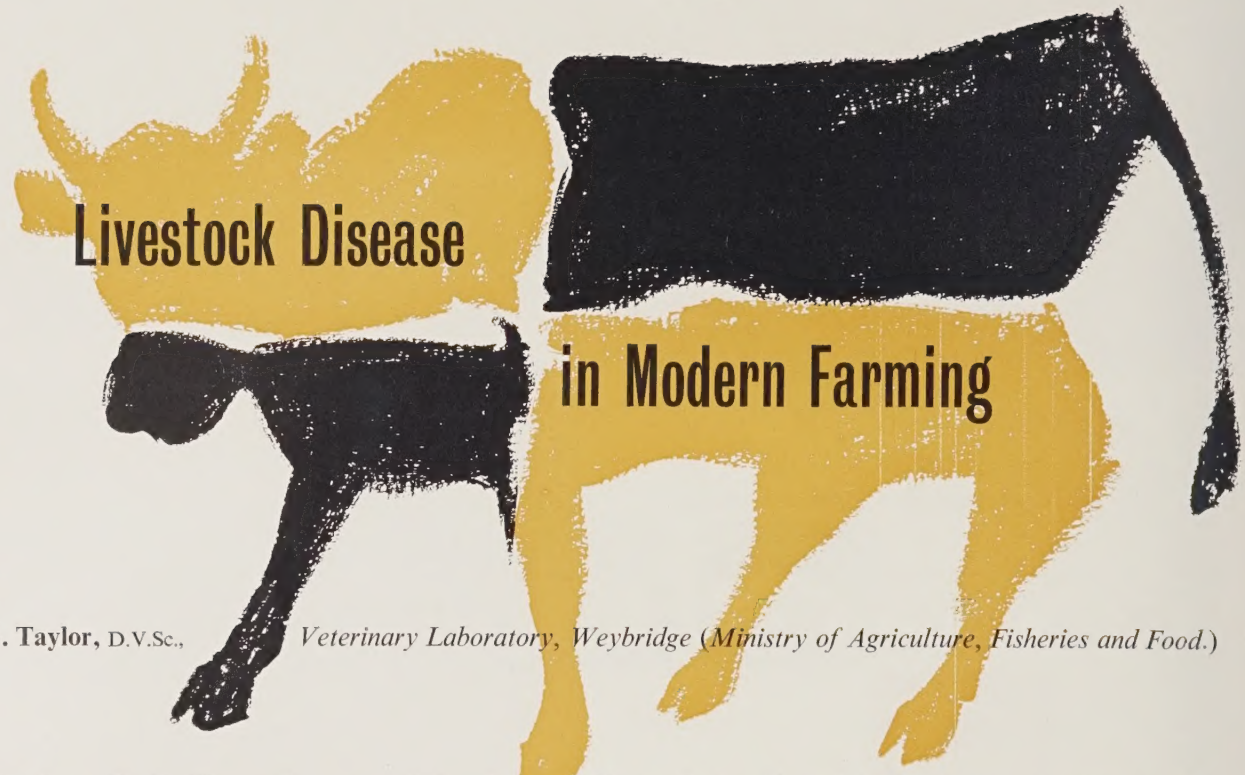


Livestock Disease in Modern Farming

by **E. L. Taylor,** D.V.Sc., *Veterinary Laboratory, Weybridge (Ministry of Agriculture, Fisheries and Food.)*

It is only since World War II that research has been recognised as an ordinary occupation of ordinary individuals. The scope for the application of the work of these people to agriculture is limitless so that numbers of the new discoveries of the zoologist, botanist, geneticist, physicist, chemist, engineer and veterinary worker have an immediate bearing and provide something new for the progressive agriculturalist to try. Many of these steps imply an alteration in the balanced community of living things, often recognisable to us as disease.

The successive steps in the process of intensification are made alternatively by the small group of research workers, handling theoretical considerations in laboratories, and a larger group of veterinary clinicians, in close touch with the practical farmers. These observers report evidence showing that the even tensions among living things have been deranged in a new direction. The research group then try to find the reason and an adjustment is made, often in the form of an additional artificiality. An important point to observe is that these adjustments are in no way permanent; whatever the artifice may be its operation must continue or the tensions again become uneven and disease appears. It is, in fact, a conventional world of plants and animals and not a natural one.

At this point reference might be made to the tendency for a change to take place in the position of the veterinary clinician who is concerned less and less with individual animals and to an increasing degree with groups. He deals with subclinical disease among flocks and herds, looking for the first signs of departure from normal health and into the fine points of adjustment that maintain the balance. His clinical knowledge is employed in detecting these early changes and determining their cause, and for this he deals with individuals; but his treatment, both prophylactic and therapeutic, most commonly concerns the whole group.

I will endeavour to deal with some of the things that we have learned by these trial-and-error methods under three headings: Conventional Animals, Conventional Foods and Conventional Microbial Background.

Conventional Animals

The slow process of selective breeding has already modified the anatomy and physiology of our domestic animals and birds with the object of enhancing production. Some of the evil consequences of these deviations from the natural are familiar, such as the susceptibility of the mammary gland of the cow to bacterial invasion, or of the fleece-covered sheep to the fatal disease of sheep scab. These changes had happened prior to the introduction of intensive agriculture, which has brought with it an entirely new set of troubles, concerned, strangely enough, with the successful suppression of bacterial pathogens. The usual way for an animal to develop its defence mechanisms against the microbial world is to receive antibodies from the dam before birth takes place, or soon afterwards through the colostrum. The newly born animal, thus passively protected against the first contacts with pathogens, is given a breathing stage in which actively to provide its own more powerful antibodies.

It is this essential step in the development of a normally resistant adult animal that we prevent by the continuous use of antibiotics in early life, depriving our conventional animals of their normal preparation for life in a world of microbes. It is a danger that was, perhaps, exaggerated when first it was recognised, but we must be just as careful

now not to underestimate the possibilities that accompany the introduction of each new and powerful protecting agent. The new parasiticides and protective vaccines against parasitic bronchitis provide an example. Wherever the re-introduction of a pathogenic organism cannot be avoided we must keep in mind the danger of producing susceptible flocks and herds.

Conventional Foods

In the earlier period of our scientific agriculture the agronomists were satisfied with the investigation of naturally occurring herbage plants, to discover which species produced the most digestible herbage. The next step was to improve each useful species by judicious selection and controlled pollination. By this means numerous strains were produced far exceeding the normal grasses in nutritive value, so that we were provided, not only with conventional pastures for the conventional animals to graze, but conventional plants growing there as well.

In theory this is all to the good. Even extensive field trials, however, may fail to reveal what ultimately becomes only too plain to the agriculturalist and his veterinary adviser. An excellent example comes from Australasia where, in parts of marked climatic variance the successful development of animal husbandry has depended upon four pasture plants, all of which are associated with specific disease problems: wild white clover with bloat, perennial ryegrass with facial eczema and ryegrass staggers, *Phalaris tuberosa* with Phalaris staggers, and subterranean clover with prolapse of the uterus and infertility. All are prevented by the substitution of a mixed herbage, such as more nearly approaches the natural.

The same kind of thing operates against the utilisation of the wonderfully nutritious grasses that have been developed for our pastures—the animals prefer not to eat them! At least, it is so in many instances, where they are seen to leave the luscious green sward that looks so appetising in our eyes and prefer to graze the benty growth of inferior grasses and weeds that line the hedgerows. It is thought to be a matter of palatability, and here I should like to ask the research people the reason for our not using the appropriate sense organ in the investigation of this point. One can imagine the son of some wine-tasting expert, after serving his apprenticeship, entering a veterinary laboratory in order to apply the same methods to the recognition of the flavours of grasses and after some years of practice on filtrations from the pulverised leaves, being able to recognise bovine appreciations and know what is of good vintage. He would then direct the course of research towards improvement of strains that would not only please the analyst but the cow as well.

Hypomagnesaemia may be mentioned as a clear-cut example of the association of disease with conventional pastures. In recent years its connection with rapidly growing herbage has been clearly recognised and widespread outbreaks are sometimes seen to accompany seasonal variations in the weather, such as bringing about a rapid growth of herbage as, for example, in the widespread occurrence of the disease in the south-western counties of England during the late summer of 1958. An association is also seen with the intensive grassland systems of ley farming or of the increased use of nitrogenous fertilisers such as force a rapid growth of lush herbage. How such grass causes hypomagnesaemia is not clear and the suggestion of an association with excessive amounts of ammonia in the rumen, and a consequent depression in the absorption of magnesium, can be regarded as little more than a working theory.

These are examples of situations in which clinicians report on the type of disturbance following the introduction of intensive methods, and the circumstances under which they occur. In several instances we know of some practical way of avoiding the loss. The precise reason for its occurrence often, however, remains a problem for the laboratory worker. It was through investigations into such a problem that we were led to the knowledge that a trace of cobalt is an essential part of the diet of ruminants, in order that their microbial associates may synthesise a complex substance, vitamin B_{12}, that is essential to the life of the host animal, but can only be obtained through the activities of certain microbial associates in the presence of cobalt. Apparently this vitamin does not occur in plants, it being necessary for it to be synthesised by bacterial action—which reflects again the essential interrelation between the complex vertebrates and the bacterial environment in which they live, and shows the breadth of the field that confronts the veterinary investigator.

Conventional Microbial Background

Continuing with our consideration of the disintegration of the natural biological world we come to a very interesting chapter, introduced by the isolation of penicillin. Some indication of the importance of the normal microbial associates of domestic animals had already been obtained in connection with digestion in stomach and intestines, but it was not until this new kind of substance empowered us to interfere in a big way with bacterial populations that we began to see the true nature of the *status quo*.

This field for investigation is an exciting one. It was the farmers who hurried along to make practical use of the new discovery and mixed antibiotics with the animals' food, and it was exciting for the bacteriologists to observe a more marked effect on some farms than on others. It was not the pigs that differed, nor the places in which they were kept, nor the food or management, but the microbial background of the environment. Animals that we had considered to be perfectly normal and healthy were revealed by this means to have been growing at a sub-optimal rate because of slight differences in the microbial populations of their intestines and the environment in which the animals were living.

It is interesting that the first evidence should have been of favourable possibilities through interference by the use of these newly discovered substances. We have since seen more of the possibilities for evil. There is a long list of reported intestinal ills and pathological conditions due to organisms that in the ordinary way occasion no trouble

These animals look healthy enough, but grazing poses the veterinary surgeon with numerous problems connected with both nutritional and parasitic disorders.

at all so long as the normal tensions are maintained.

There are, however, a number of organisms that may be regarded as on the fringe of pathogenicity, in the position of waiting to occupy living space but kept in abeyance by competitors and host resistance. The powerful new antibiotic substances, in suppressing some components of the bacterial populations of the intestines, alter the ecological balance and a pathogenic role is taken on by organisms that in the ordinary way are quite harmless.

There is still plenty of romantic exploration to be carried out in research, but anyone who seeks real adventure in a research career should go into virology at the present time. The exciting discoveries here are tumbling in too rapidly for anyone outside the specialised field to keep abreast. Whoever browses through the reports of new observations, however, gets a vague sense of a background of viral entities in which tensions exist. There are normal and abnormal associations between vertebrates and their viral environment, as well as the microbial environment that has been discussed.

The romantic appeal in this work is reflected in the use of the term 'orphan viruses', described as 'viruses in search of a disease'. Numerous examples of these entities have been recognised since the development of tissue culture methods and a new practice has sprung up among the virologists who fill papers increasingly with references through initial letters to MHV (mouse hepatitis virus), EEE (eastern equine encephalitis) and the host of enteric cytophogenic orphan viruses, ECHO, ECMO, ECBO, and ECSO, enteric cytopathogenic viruses of human, monkey, bovine and swine origin respectively. Each of a dozen or more recognisable strains, some only of which are so far known to be capable of producing pathological effects in living animals.

Eradication of Pathogens

The road ahead, of increasing intensification by trial-and-error procedures, entails continuous readjustment for the deranged ecological relationships. It looks like an uneasy course. There is, however, one bright spot on the horizon of the future, concerning those essential pathogens that it may be possible to eradicate. Here is a field of activity for the veterinarian of the future.

This idea of eradication is in the air at the present time, through outstanding success in the tuberculosis campaign, and a word or two might be said about the general prospects, concerning the helminth parasites of grazing animals. The diseases which they cause form a special group, being definitely linked with concentration of animals on pasture ground. As the intensity of the use of improved grassland increases, therefore, we must expect increasing trouble from parasitic worms.

This is not the place to enter into detailed considerations and I must be content with conclusions reached, that the eradication of some of the worst kinds of parasitic worms from almost any farm is within the bounds of possibility, but only at very great trouble and expense. In view of the great probability of early reintroduction it would therefore be unwise to make the endeavour, and quite impracticable at the present time to eradicate the parasites from the country as a whole. For each group of these parasites a time will come, however, when the question of relative costs will have to be worked out carefully: should we continue this recurrent expenditure on control measures, along with the inefficient use of our improved pastures, or should we make one concerted and expensive onslaught and endeavour to eradicate the parasite?

The time for this onslaught may come along more quickly than we expect, as in the outstanding example of the eradication of anopheline mosquitoes from large islands and from large areas of the mainland, through the use of modern insecticides; and the complete elimination of the nodular worm of sheep from the eastern provinces of Canada by the use of phenothiazine during the period of their winter housing. It is not unlikely that it will be the discovery of new anthelmintics of unheard of efficiency that will ultimately enable us to proceed with the eradication of parasitic worms.

Until such time arrives, however, we must learn how to live with these worms, by the use of such parasiticides as we have and the adaptation of husbandry methods. These are not without hope and it is a great encourage-

ment to see the complete disappearance of some of our serious problems. Syngamiasis is a case in point. At one time this was perhaps the most serious disease with which the rearer of chickens had to contend. Ground that had been used for the rearing of chickens could not be used again for several years when once the parasite had been introduced by wild bird carriers and the rearing of chickens in many places was entirely abandoned. This serious trouble completely disappeared with the introduction of the intensive system of rearing chickens and a generation of poultry keepers has arrived who have only heard of the condition as part of the history of the past. Trichomoniasis in cattle is another example of the same kind. In this instance it was the introduction of artificial insemination that was responsible. The same sort of thing might happen with the development of 'zero grazing', or, if we look still further into the future, in the 'three dimensional' agriculture that is to come, when grazing animals are brought indoors and their food is protected from faecal contamination.

Underlying Principles

The appearance of new forms of disease is one of the essential elements of progressive agriculture and is brought about through alternation of the relationships between the innumerable forms of life that fill every available niche, and that depend upon one another for the health and for the permanence of their communities. Most of these forms of disease represent only a temporary hindrance to progress, as when once the deranged detail has been ascertained we are able to make the necessary adjustment. It is, however, recurrent and we must expect new diseases to accompany each successive step in progress.

The difficulty in our understanding, and our inability to proceed by anything other than trial-and-error methods arises through the complexity of the numerous forces in operation. Evidence of this is seen in the use of such terms as 'balance', 'tension' and 'background' where we should like to be more specific. There is also the human difficulty of looking at things objectively. It is essential to take the objective view if we are to make the best use of our limited powers of understanding; and here again we find evidence in the use of terms: the word 'parasitism' is used in a familiar fashion by the specialists who, however, make no use of the word 'hostism' and yet those two are complementary ideas and represent two aspects of one and the same phenomenon. 'Hostism' is the parasite's point of view and is of equal importance with 'parasitism' in understanding the relationship of the two.

The phenomenon of 'parasitism' must not be regarded as curious and exceptional, nor parasites as occasional and odd; even in the diversity of their form they are more numerous than the hosts on which they live. Not to take their point of view into account is unreasonable. There are good hosts with which a parasite community may live happily and there are bad hosts that react in an unfavourable way and produce disease in the parasite community—it is more than a parallel case, it is an identical one.

This situation may be sensed most readily by the worker with the gross parasites, where the onset of sickness can be seen in each individual; female nematodes 'go off their lay' and young cestodes cease to grow as they ought to do. The larger parasitic worms assume an individuality, on which account it seems natural to study their well being and to see the mirror-image of the host's disease. In this situation 'resistance' and 'adaptation', 'competition' and 'co-operation', are seen to be facets of one and the same phenomenon. There are sound reasons for thinking that given the necessary technical skill and the ability to provide for the needs of the parasite it would be possible to manufacture vaccines to protect their young against the harmful effects of the host, just as it is possible to do the reverse. Such a duality of operational forces is less easily conceived among the rabble of bacteria or in the background mist of viruses—and yet the situation is the same and similar responses must be in operation.

It is through groupings such as this that we find the principles which serve to guide us towards an understanding of natural things, where the complexity of detail merely confuses. Principles like the following are useful:

(1) All animal life depends upon the support of other life and on complementary adaptations;

(2) Parasitism is one of the principal ways of getting a living;

(3) Good, healthy 'parasitism' allows the host community to live;

(4) Good, healthy 'hostism' allows the parasite community to live;

(5) An all-important background exists of microbes and viruses that are kept in their places by competition with one another and by a balance of resistance and acceptance on the part of the host;

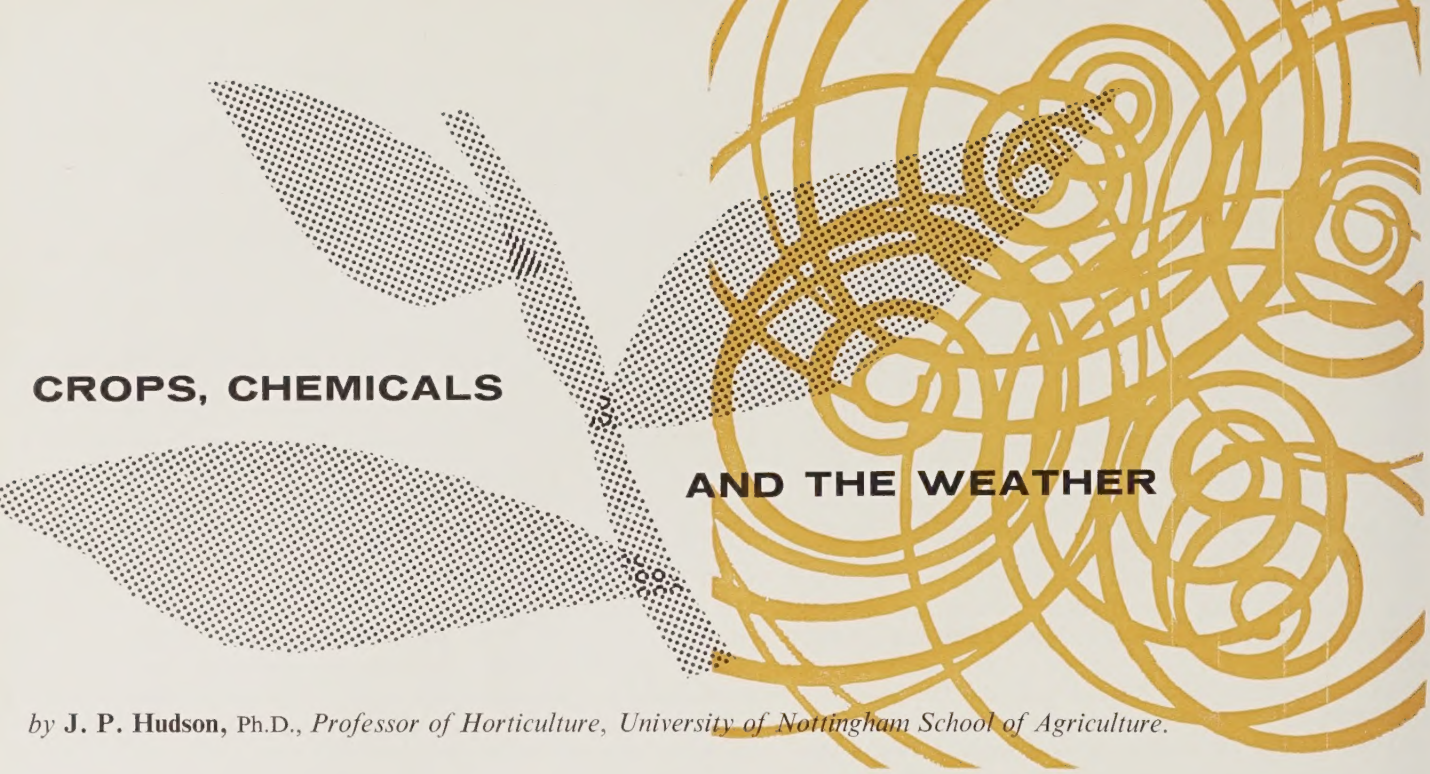
(6) All of this has come about through parallel evolutionary development and represents a healthy environment.

Progressive agriculture produces a disease environment by upsetting the natural adjustments, and continually advancing production can only proceed through constant re-adjustment of the uncertain new relationships. Nothing of this is permanent.

In a story entitled *Letting in the Jungle*, Kipling describes the rapidity with which a forest village disappeared once man had left it. The same applies to all conventional animals, conventional pastures and conventional microbial background: they can only be maintained by constant attention, and in the end we find, paradoxically, that the jungle is the only orderly arrangement of living things.

Acknowledgement

The above article is the major part of a paper entitled The Relationship between Intensive Agriculture and Animal Disease, *which the author read at the annual congress of the British Veterinary Association last September. It is reproduced here by permission of the Association and Dr. Taylor.*



CROPS, CHEMICALS AND THE WEATHER

by **J. P. Hudson,** Ph.D., *Professor of Horticulture, University of Nottingham School of Agriculture.*

Crop plants rarely yield to full capacity and adverse weather is one of the factors which commonly cause loss of potential crops. Farmers can do little to control the weather, apart from the use of irrigation to keep the soil moist, but it may be possible to increase yields under adverse weather conditions, since experiments have shown that plant responses to weather can be changed by the use of chemical treatments. A new field of research is developing in the study of chemical modulators which will cause plants to grow better under adverse conditions.

Crop yields vary tremendously from year to year, on the same farm and under the same management, and these variations are largely due to differences in the weather. Horticulturalists often exercise a degree of control over the plant environment, especially in the more intensive forms of production using glasshouses, but it is difficult to change the weather on a field scale and farmers have to accept the day-to-day conditions with such philosophy as they can muster. Agricultural scientists are now asking the question whether we need be so dependent on the fickleness of climate.

Once the effects of weather are precisely understood it might be possible to change the responses of plants to the weather in such a way that they will grow better, and yield heavier crops, under weather conditions that are not ideal. This is not a pipe dream, since recent experiments have shown that it is indeed possible to change the responses of plants to weather, although a great deal more work will be needed before this new approach becomes a practicable proposition.

To understand the relation between plants and the weather it is necessary to distinguish between two different aspects of plant behaviour, namely the kind of growth the plant is making and the rate at which that growth is being made. These two attributes, one qualitative and the other quantitative, are distinct, and may be influenced in different ways by the same weather conditions. Thus it is essential that they should be considered separately, although, of course, both processes occur at the same time.

Type of Growth

Looking first at the kind of growth: the life cycle of any plant can be divided into a number of distinct phases, in each of which it behaves quite differently. The phases are largely determined by what happens at the growing points of the stems, where one of several things may occur, as follows:

Virtually no change (as in dormant seeds or, at certain times, in buds, although there is often great activity in apparently 'dormant' buds).

New leaves may arise around the growing point. These leaves may start to expand at once, or may remain in the embryonic stage without further development for the time being.

The stem tissues between leaves may grow, or not. If the former, the shoot becomes longer, but often leaves grow bigger without the internodes elongating, in which case a rosette develops, where the leaves are close together instead of being spaced out along the stem.

Rudimentary buds are usually formed in the angles where leaves join the stem. These buds may remain small, because they are generally 'dominated' by the terminal bud, in which case the stem is unbranched. Alternatively, the apical bud may lose its dominance, and the side

buds start to grow out, in which case the plant becomes branched.

The growing point may cease to lay down new leaves and produce flower buds instead. These may continue to grow until flowers are visible, or they may remain dormant for prolonged periods, often (e.g. in perennial fruit plants) until they have experienced a period of cold to 'break their dormancy', a useful natural safeguard to prevent flowering shoots from starting to grow in a spell of mild winter weather.

Finally, the growing point may die.

Each of these types of behaviour is clearly different, and the passage of a plant from one phase of development to the next is due to the growing point ceasing to behave in one way, and starting to behave in another. It is believed that this change in behaviour is controlled by changes in the balance between various growth substances (1), the plant hormones, which occur naturally in all plants. They are typically produced in one part, such as a leaf, and passed to another, such as the root, or vice versa, giving rise to the all-important 'correlations' which ensure that the plant develops in a balanced way. This balance can be affected by changes in day-length, temperature, and other factors of the environment, resulting in the different types of behaviour that are characteristic of the various seasons of the year in a temperate climate.

If this balance could be altered it should be possible to change the plant's behaviour in relation to the weather—for example, to make shoots grow in length when they would normally rosette, or cause side shoots to grow out when they would normally remain dormant, or induce flowers to develop earlier or later than would normally occur under natural conditions. All these, and many other, effects could conceivably have practical uses in the control of cropping in agriculture or horticulture.

These points can be illustrated by reference to the raspberry plant, *Rubus idaeus*, which, though not a major crop in itself, is a species of great interest to the research worker. Raspberry shoots arise from buds on the roots, which are capable of growing out in response to suitable temperature conditions at certain times of the year (4). Each shoot then passes through a series of no less than nine distinct phases of growth in the course of the next two years (Figure 1), culminating in the production of fruit and ultimately in the death of the shoot towards the end of the second summer (5).

Each of these phases is distinct and differs because the growing points of shoots are behaving differently. The passage of the shoot from one phase to the next is largely determined by changes in temperature and day-length and the value of raspberries in experimental work lies in the fact that plants can be 'held' in any particular phase, by putting them under controlled conditions in growth rooms where they will remain in that condition (e.g. dormant, rosetted, or growing) for long periods of time. The plants can then be treated with various chemicals to see whether they can be induced to progress to the next phase whilst still under the influence of weather conditions which would normally prevent that from happening. It proves that

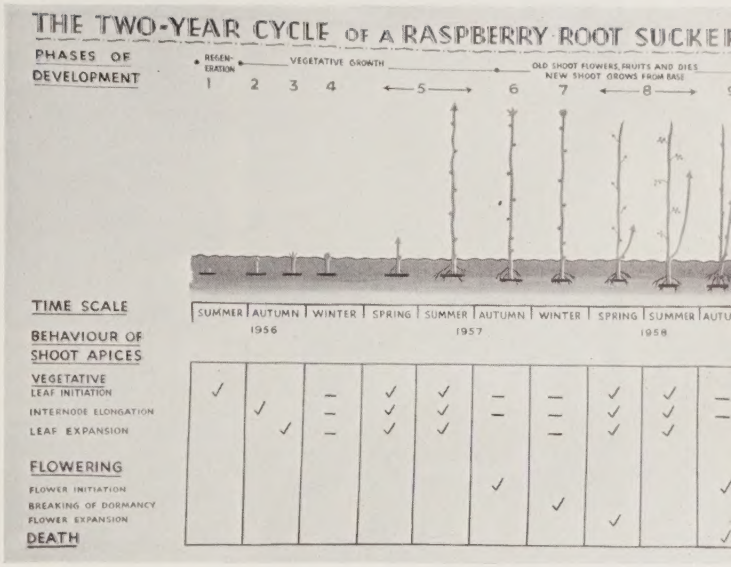


Fig. 1. The nine phases of growth through which a raspberry shoot passes in the two years following its initiation as a bud on the root showing the behaviour of the shoot apex associated with each phase of development.

Fig. 2. Three raspberry plants, all of the same age and grown in the same environment, where the normal response is to produce a short leafy stem (left hand plant). In the centre plant, regular applications of gibberellic acid to the original shoot (left) have caused it to elongate, whilst a basal shoot, which would not normally have grown until the following year, has also elongated, although it has not received any GA direct. The plant on the right received one treatment with GA on the original shoot (left) which elongated a little and then ceased to grow, but the basal shoot continued to grow even after GA treatment ceased.

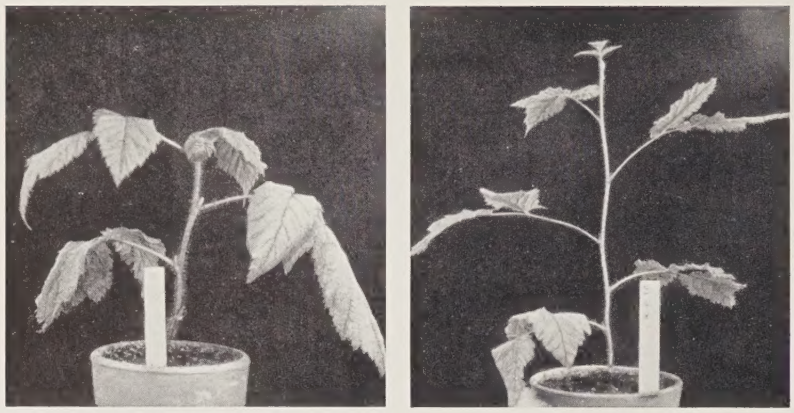


Fig. 3. Raspberry shoots cease to grow at temperatures below 55°F. and short day-lengths, forming terminal rosettes of leaves (left-hand plant). Rosetted shoots can be stimulated into growth under these environmental conditions by treatment with gibberellic acid (right-hand plant).

Fig. 4. Raspberry shoots do not usually form branches, but side buds can be stimulated into growth by treating the tips of the main shoots with tri-iodobenzoic acid. The side shoots elongate at relatively high temperatures (left) or form lateral rosettes at lower temperatures (centre). A combination o kinetin and indolyl acetic acid has similar effects (right).

there are many interesting possibilities. For instance, shoots can be made to grow under conditions where they would not normally elongate (Figures 2 and 3), or to branch when branching would not normally occur (Figure 4), or to open their flowers without the dormancy of flower buds first being broken by a period of cold.

Rate of Growth

Turning to the other aspect of behaviour, which is concerned with rates of growth, it is clear that any of the processes referred to above might take place at different speeds, so that new leaves are laid down slowly or quickly, or unfolding leaves barely expand or grow fast, and so on. In agriculture it is generally, though not always, an advantage for growth to occur quickly, as in a 'good growing season'.

As in the case of the different types of behaviour, growth rates are also affected by many factors, including temperature, water and mineral nutrients. Dealing with these factors in the reverse order, the use of fertilisers can ensure that growth is not checked by lack of nutrients, whilst irrigation can be used to supplement rainfall so that yields are not limited by drought, but temperature is difficult to control. However, work in America, notably in the phytotron of the Earhart Plant Research Laboratory in California, has shown that various chemicals can be used to prevent plants from being damaged by excessively low or high temperatures. For instance, pea plants can be protected from damage due to high temperatures by the application of adenine, while the chemical thiamin can increase the growth of *Cosmos* at temperatures much below the optimum for that species (2).

Although these findings are at present mainly of academic interest they suggest interesting possibilities of increasing the rate of growth where temperature is preventing plants from growing as they should. However, care would be needed in the use of growth stimulants in that way. It is difficult to judge rate of growth by eye, and it is often assumed that a plant is growing all right if it looks all right, but that is far from the case. Growth rates fall off long before plants show any visible signs of distress and plants are poor indicators of their current needs for water or nutrients until they have gone seriously short of their requirements. Thus there might be a real danger of applying the treatment too late, when it can no longer be effective.

The same limitation would apply to the use of chemical modulators for changing the phase of development, which initially occurs at the microscopic level, long before the organs concerned are visible to the naked eye. Indeed, the use of chemicals for stimulating growth or modulating behaviour could only be successful if it were based on a precise knowledge of the factors which are limiting the rate of growth or preventing a plant from passing to the next phase of development. This involves, first, a detailed study of the stages through which a plant passes in its life cycle, and then experimental work to find out the limiting or controlling factor or factors at each stage. Few crop plants have yet been studied in such detail, but this type of preliminary work is essential, since chemical modulation can be little more than a hit and miss technique unless it is used with precise knowledge of the phases of development and the effects which weather in the immediate future is likely to have.

Range of Chemical Treatments

Many materials have possibilities as stimulants of plant growth or modulators of plant behaviour. The outstanding case at present is gibberellic acid, which can replace the effects of long days in the initiation of flowers in some species, prolong dormancy in vine, prevent leaves of deciduous trees from falling in early autumn, increase the length of shoots of many species, and induce other reactions of great potential agronomic interest. The rapidly growing literature on the manifold effects of gibberellic acid has recently been reviewed in detail by BRIAN (3) and WITTWER and BUKOVAC (7).

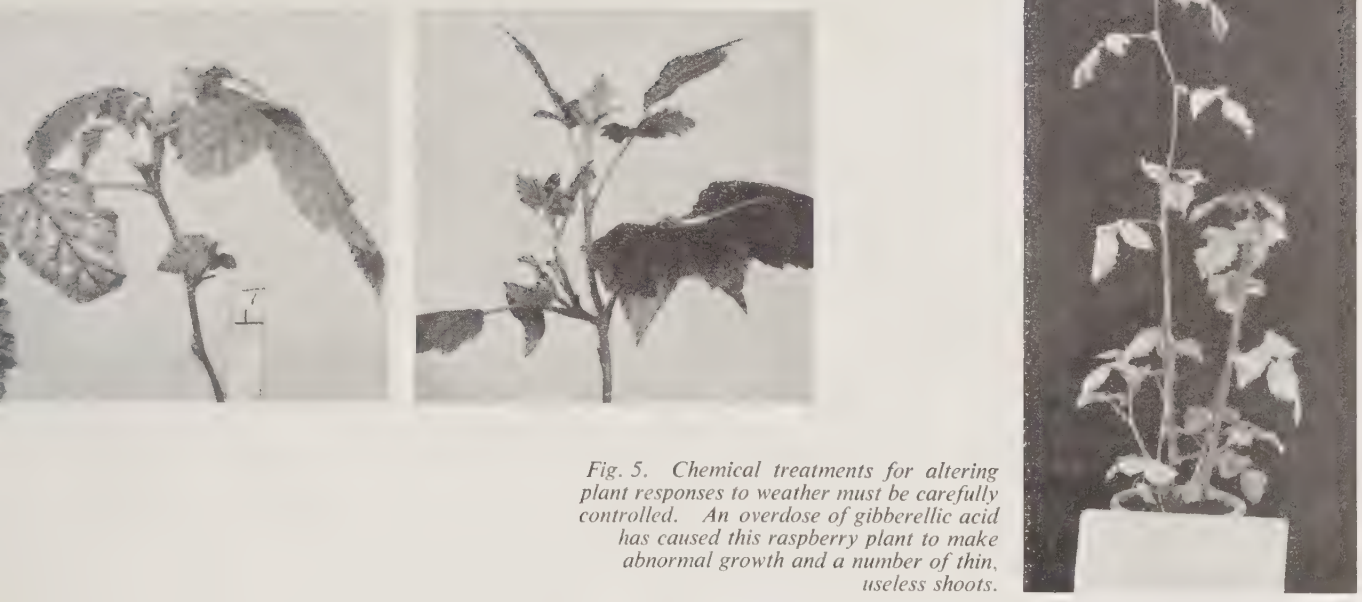


Fig. 5. Chemical treatments for altering plant responses to weather must be carefully controlled. An overdose of gibberellic acid has caused this raspberry plant to make abnormal growth and a number of thin, useless shoots.

Other materials have also been reported to influence one or other aspects of growth or development. For instance, chemicals such as thiourea and kinetin can cause certain types of seeds to germinate under environmental conditions where they would normally remain dormant (6). Kinetin, in the presence of minute amounts of indolyl acetic acid, has been shown to stimulate the production of buds in plant tissues and might prove to be an effective agent for inducing plants to branch more than would normally be the case (Figure 4). Maleic hydrazide is one of a number of substances that are capable of retarding growth in certain circumstances, but without killing or seriously injuring plants—a useful technique where it is desirable to suppress suckering, delay flowering, or induce dormancy (or even, perhaps, to slow down the growth of lawn grasses or hedge plants to reduce the need for frequent mowing or clipping).

In the case of the raspberry plant, work in this Department has shown that elongation of the stems can be encouraged by spraying with gibberellic acid under weather conditions that would normally prevent the shoots from growing; applications of tri-iodo benzoic acid, maleic hydrazide and kinetin have all stimulated lateral buds to grow, causing branching of shoots that would not normally have produced branches at all; while gibberellic acid has apparently broken the dormancy of fruit buds so that they could grow out into fruiting branches without the need for winter cold. The last point is of some practical significance since lack of cold winters limits the areas where raspberries can be grown and chemical treatment might enable the geographical distribution of the crop to be widened.

Although this approach to the control of plant behaviour offers great possibilities—perhaps the most exciting since the discovery of fertilisers a hundred years ago—there is need for a note of caution at the present stage. So far as fertilisers are concerned, the plant depends almost entirely on external resources for its supplies of mineral nutrients and it is not therefore surprising that there are rewarding responses to the application of materials which are in short supply in the soil. But the plant already has its own internal system for regulating development and growth, and this system is one of great delicacy and exact balance. Before any useful purpose can be served by the use of chemical treatments it will be necessary to define precisely the phases of growth and development of any particular crop plant, the effects of weather on these phases, and the exact modification of the normal pattern of behaviour which it is desired to produce (Figure 5).

It is apparent that the application of chemicals as growth modulators will require much greater skill and subtlety than treatment with fertilisers—not only might incorrect dosing lead to disaster but even applications at the right level might sometimes achieve the desired effect and sometimes fail altogether unless the materials are applied from a position of knowledge. Nevertheless, with these reservations, it seems possible that chemical modulators may provide a major new development in crop husbandry, enabling the farmer, for the first time, to break the grip of the weather on his crops and prevent adverse weather from depressing yields to the extent that we now regard as inevitable.

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Agricultural Research Stations—3.

The USDA Agricultural Research Centre

by **Byron T. Shaw,** Ph.D., *Administrator, Agricultural Research Service, US Department of Agriculture.*

The USDA Beltsville Research Centre, Maryland. The building in the foreground is that of the Cartographic Division of the Soil Conservation Service. Other buildings house the research activities of the Institute of Home Economics and the Entomology Research Division.

(Photo: USDA)

At Beltsville, Maryland, just a twenty-minute ride from Washington, DC, 11,000 acres of rolling and partly wooded land have been dedicated to the American tradition of better farming through science. Here, at the Agricultural Research Centre of the United States Department of Agriculture, is the hub, the point of focus, of a co-operative agricultural research system that reaches into every State in the Union. There are strong ties between the Centre and agricultural research in US territories, and in many foreign countries.

Here in the laboratories and greenhouses, and on the experimental pastures, ranges, orchards, gardens, fields and timber stands, some twelve hundred scientists conduct their investigations. More than that, the Centre is headquarters for research by an additional 3,600 Department scientists at some 600 field stations, many of them co-operative establishments of the Department and the State land grant colleges and universities.

The Centre has contributed to the progress of American agriculture since 1910. It was in that year that a Congressional appropriation of 25,000 dollars, for additional land for animal husbandry research, was used to purchase 475 acres of the present site. Expansion to the present 11,000-acre Centre has come gradually through the years. In all, the Government has invested some 13 million dollars in land, buildings, equipment, and roads.

During this half-a-century the face of American agriculture has been changed through the contribution of science and technology stemming from the Agricultural Research Centre and from the vast co-operative research system of which it is a part. During this time America's agriculture has grown to be one of the most efficient and productive in the world.

Manpower requirements provide a significant measure of progress through research. In World War I, American farm commodities were produced by 13½ million workers; in World War II, by 10½ million. Today there are only 7½ million farm workers.

If the agricultural output achieved in 1957—the latest year for which figures are available—had been produced by the methods available to farmers in 1939, it would have cost the nation about 7½ billion dollars more in land, labour, capital, and other resources than the actual cost in 1957. Because of research, these 7½ billion dollars were available for other improvements in the American living standard.

Achievements at Beltsville

Below are outlined some of the specific contributions of scientists at the Agricultural Research Centre.

Animal and Poultry Breeding. Poultry scientists successfully bred the small white Beltsville turkey, an achievement that has helped to popularise turkey meat as everyday fare. Others contributed to the nutritional and breeding improvement of poultry and thus to the billion-bird-a-year broiler industry.

Other scientists at the Centre have contributed to the development of meat-type hogs that produce more lean and marketable meat, and hybrid lambs that gain faster, grow larger, and produce more and better wool.

Veterinary Research. The antibrucellosis vaccine—strain 19—now widely used in the fight to eradicate this cattle disease from the United States, was first produced at Beltsville. Animal disease scientists at the Centre have also contributed the use of phenothiazine for removing injurious worms from various types of livestock, and the use of sodium fluoride for freeing swine of roundworms.

Dairy Cattle. Dairy research with a Holstein herd established at the Centre in 1918 has shown how the use of proven sires has raised the butterfat production per cow 30 per cent through the years. This herd is now serving research to establish the relative merits of using unrelated proven sires, of selection and inbreeding, and of cross-breeding. Dairy physiologists are currently carrying forward basic research in animal metabolism that will ultimately contribute to more productive, weather-tolerant cattle for various regions of the US.

Crop Improvement. Thirty-one greenhouses are devoted to the year-round improvement of farm crops to give them higher yields, better quality, and disease resistance. The work of scientists at the Centre with crops contributed to the development of stem rust-resistant wheats for the northern great plains, to hybrid onions, virus-free strawberries, improved grasses and alfalfa varieties, and to such specialised plant varieties as lima beans of different sizes, larger-flowered lilies, and short-stemmed chrysanthemums.

It was at the Beltsville Centre that Department scientists discovered the principles of photoperiodism—the effect of light on plant growth. This basic discovery has not only explained much that was previously unknown about the flowering and fruiting of plants but has proved to be a valuable tool for both plant breeders and commercial nurserymen.

Beltsville scientists have given the world much that is now known about plant growth regulating chemicals. They not only carried forward development research that has led to the broad scale use of such effective weed killers as 2,4-D, fruit thinning sprays, and the amazing gibberellins that make short plants tall; they have dug deeply into chemical-plant relationships to show how chemicals do their work; how dalapon, for example, attacks grassy weeds by inducing a vitamin deficiency; how another new, promising herbicide, simazin, controls weeds in corn

because corn contains an enzyme that makes simazin harmless, while weeds do not.

Aerosols. Other workers developed the aerosol 'bomb', which during World War II contributed to the health and well-being of many Allied servicemen by providing them with a means of controlling disease-carrying pests. Today, the aerosol is the basis of a multi-million dollar industry.

Building Design. From the Centre have come research-engineered designs that have lowered farm building construction and operating costs and improved homes and farm buildings; scientific home economics determinations have led to the convenient U-shaped kitchen, and, more recently, to the energy-saving kitchen with waist-high ovens and refrigerators.

Marketing Research. Research at Beltsville to improve the marketing of agricultural commodities has contributed to the wide and profitable use of protective plastic liners in fruit and vegetable shipping crates. For example, polyethylene lug liners are saving the cherry industry, alone, an estimated 300,000 dollars per annum. Other marketing research has shown that stored apple losses can be cut by regulating carbon dioxide content in the storage rooms to reduce the rate of respiration of the fruit. Such research also has resulted in the ' hortiscope,' an instrument that uses an elaborate light transmittance system to gauge the maturity of fruits and vegetables.

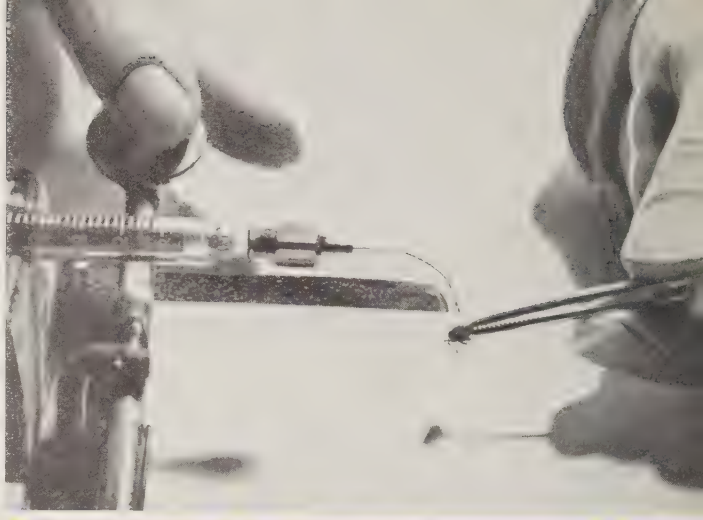
Forestry. Forestry research at the Centre has given scientists the gallic-tannic acid test, now universally used to separate cultures of wood-destroying fungi according to their enzyme systems—an important step towards a better method of identifying these fungi. Other research that has improved equipment and techniques for aerial pesticide spraying has similarly advanced forest insect and disease control.

This list of achievements indicates that not only does the Centre's basic and applied research touch on all areas of agriculture—including the production, protection, and marketing of all of the goods of farms and forests—but its research in human nutrition, clothing and housing, and household economics directly contributes to higher standards of both farm and city living.

During the Centre's history, much of the research has been, and continues to be, conducted along farm commodity lines. For example, there are currently six farm research Divisions with headquarters at Beltsville, concerned with basic and applied research related to the particular fields of agricultural engineering, animal diseases and parasites, animal husbandry, crops, entomology, and soil and water conservation. These Divisions are broken down into smaller and more specific scientific entities. The Crops Division, for example, includes research on cereal crops, cotton and cordage fibres, crop protection, forage and range, fruit and nut crops, new crops, oilseed and industrial crops, tobacco and sugar crops, and vegetables and ornamentals.

Pioneering Research

More recently—in 1957—a new concept in government-supported agricultural research became manifest at the Centre, as well as at other USDA research locations around the country. This was pioneering research—research that probes beyond the frontiers of knowledge, to find the 'unlooked for'. Pioneering research is not confined within the limitations of specific crops or animals. At the Beltsville Centre it is concerned with such broad areas as cellular metabolism, insect pathology, blood antigens, plant viruses, and the mineral nutrition of plants. Similarly, pioneering research imposes few limitations on the scientists. They are not only given maximum freedom of opportunity for thinking, observing, experimenting, and analysing, but also maximum freedom from administrative duties and responsibilities.



At the USDA Pioneering Research Laboratory for Insect Physiology at Beltsville, a scientist doses a fly with a measured drop of insecticide; later he will count and make chemical analyses of dosed flies at various intervals to determine mortality, and changes in chemical and physiological processes resulting in kill.
(Photo: USDA)

It is too early for results to be obtained from such fundamental studies, but just as similar basic research in photoperiodism years ago is providing practical help in breeding improved crops today, research now under way that will show how nutrient elements move from the soil into plants will provide more efficient methods for fertilising crops in future years. When pioneering research helps to unravel some of the chemical processes occurring within living cells, man will be much nearer to an understanding of the nature of life itself.

Research Objectives

The total of this applied, basic, and pioneering research effort at the Centre, and throughout the nation's co-operative research system, is directed toward broad, but specific objectives. The goals are: (1) to protect the productive gains that have been made in the past; (2) to help return production into better balance with demand; and (3) to guarantee an abundant future.

The head of research on cordage fibre crops, Mr. E. G. Nelson examines the new hybrid sansevieria; on either side are the two parent varieties of the hybrid, which is stated to have a high potential value as a fibre crop in Florida. (Photo: USDA)

Department scientists recognise that many of the productive gains that have been made are, at best, tenuously held, and will be maintained only through continued research and its application. For example, it is estimated that the hazards of farming—diseases, insects, weeds, weather—reduce potential production by one-fourth. Or the more practical point of view might be that these hazards reduce potential production by *only* one-fourth. Scientists and farmers alike know that it is only through the broad application of research today that the loss isn't one-half or more.

Certainly, major industries concerned with fruits and vegetables could not continue if scientists did not give a great deal of attention to the research improvement of pest control methods; and growers, processors and shippers, to their use. A recent study by a Department entomologist indicated that without insect control, the entire commercial apple crop would be destroyed by insects.

In 1950, a new race of wheat stem rust, 15B, appeared in the northern great plains destroying 25 per cent of the ripening *durum* crop. In 1952, rust took 15 per cent of the crop; in 1953, 65 per cent; in 1954, 75 per cent; in 1955, 15 per cent. During this time, scientists at the Centre and in the affected States feverishly worked together to develop varieties resistant to rust race 15B. By exploiting the USDA world collection of wheat germ plasm, and utilising greenhouses and seed increase 'gardens' in warmer climates, they developed resistant varieties in five years—a job that would normally require 10 years or more. And yet, this spectacular effort brought the northern plains *durum* grower back only to a productive level that he had known five years before.

Productive soils continue to be eroded away. Much of the limited and precious water so necessary to agriculture is wasted. But because of research the loss of soil and water is being slowly but surely reduced.

Farm Output and Markets

Research at the Centre and elsewhere which carries a step beyond helping farmers hold their own, and advances their production efficiency, is helping toward the second goal—improving the balance between farm output and markets.

Research that is taking a deeper look into the inherent qualities of farm commodities is leading to new uses and new markets for these commodities. Current research of this type, for example, is finding new uses for starches in corn and wheat, for acids in vegetable oils, and for inedible animal fats. But, at the same time, research must give farmers new techniques for producing commodities of uniform quality in high volume and at a cost that makes them both profitable to grow and competitive with other industrial raw materials. Scientists at the Centre are contributing primarily to this end.

The Future

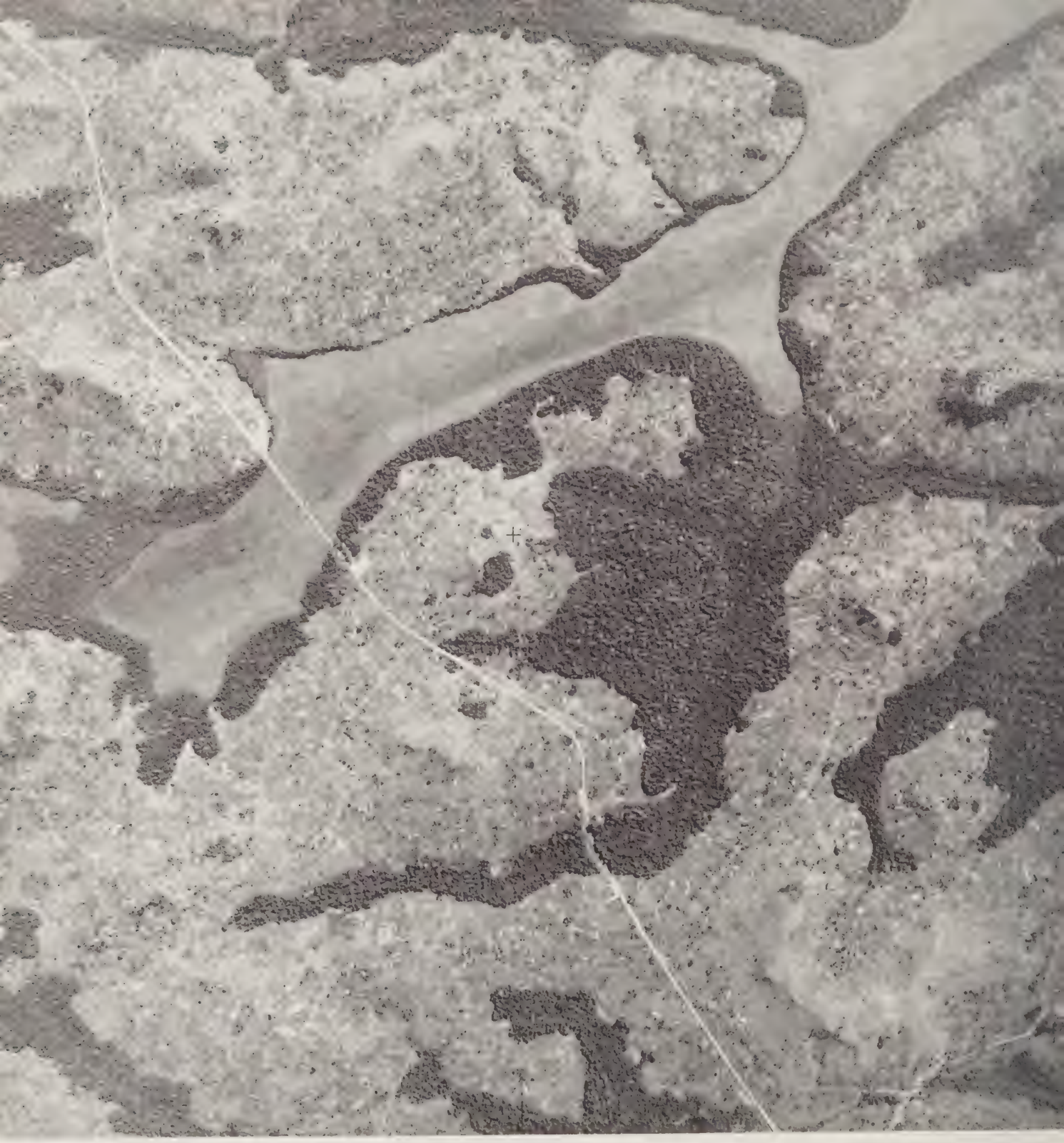
Finally, these scientists are prosecuting research now that will assure abundance in the years to come. By 2010 the American population may be double its present level. And for research, it means that in just 50 years farmers must be given the means for producing twice as much as they do today.

New knowledge of nutritional requirements, especially for older and younger age groups, is emphasising the importance of including more protective foods in diets—those high in protein, vitamins, and minerals. Meat, milk, eggs, and fruits and vegetables, the foods that provide these requirements, are also the foods that today cost the most to produce and process.

These production goals—a 100 per cent increase in crops and more than a 100 per cent increase of livestock—must be reached in a short time (as research is measured), and with only a little more land, and much less manpower.

Some new land can be brought into production. But, as the United States population increases, a considerable area of what is at present farm land will go into cities and highways. Trends also indicate that farms will continue to increase in size and decrease in numbers, and that additional farm workers will seek part-time or full-time employment in towns and cities. Research, such as that now under way at the Centre, will help meet these demands by making farming more efficient.

With continued emphasis on research, all of these goals will be attained. Farmers will successfully meet the challenge of productive hazards; new uses and new markets for farm commodities will help return production and demand into better balance, and an abundant future will be assured. The Agricultural Research Centre, by its direct scientific contributions, its guidance of Department research at other locations, and its part in co-operative research nationally and internationally, will play an important rôle in reaching these goals.



An aerial photograph of a valley-swamp south of Entebbe, showing old and new road crossings under which the water flows through culverts.
(Photo: Uganda Land and Surveys Department.)

The Swamps of Uganda

by **L. C. Beadle,** *Professor of Zoology at Makerere University College, Uganda.*

A hydrological sketch-map of the Lake Victoria Basin and the two Great Rift Valleys. (*Map: A. Luck*).

The agriculturalist in the tropics is constantly seeking ways and means of meeting the demands of humus-hungry soils. In the following article the author discusses the exploitation of Uganda's vast area of permanent swampland, wherein lies an immense and virtually untapped source of organic matter in the form of peat.

In discussing this subject, Professor Beadle, who is directing a research scheme on tropical swamps supported by the Nuffield Foundation, examines the influence of swamplands on two human diseases—malaria and bilharzia.

Dramatic earth movements in the comparatively recent geological past have resulted in most of the watercourses of Uganda becoming levelled and slow moving, and consequently choked with swamp vegetation. The products of soil erosion, instead of being carried down to the lowlands or into the sea, are mostly deposited in the Lake Victoria basin where the swamps and lakes act as gigantic compost pits and settling tanks for the eroded material.

In Uganda alone there are some 2,500 square miles of permanent swamp and as much land again is temporarily inundated in the wet seasons. Below some of the permanent swamps there are deposits of peat more than 30ft. deep, and we have here large reservoirs of substances which might in some way be used for the cultivation of plants and animals.

The Governments of Uganda and of the neighbouring Belgian Mandated Territory of Ruanda-Urundi have recently supported investigations on possible methods of exploitation and the Nuffield Foundation is financing a small research team based on Makerere University College, Kampala, to investigate some of the more basic problems in the chemistry of the decomposition processes, and in the physiology and ecology of the plants and animals. This research has some relevance both to agriculture or other exploitation of swamp lands and to the control of malaria, bilharzia and certain diseases of domestic animals.

The dominant plant in the permanent swamps is usually, though not always, papyrus (*Cyperus papyrus*), whose densely packed stalks rise to a height of about 15ft. from a floating mat of intertwined roots embedded in a mass of mud and decomposing plant remains. There may be several feet of water below this mat through which pieces of partially decomposed vegetable matter are continually falling and accumulating at the bottom as a layer of peat. Owing to intense bacterial activity the dissolved oxygen is normally entirely exhausted and the organic matter is preserved and subjected only to the extremely slow processes of anaerobic decomposition, but, as soon as the peat

is drained the organic matter is very rapidly decomposed by oxidation.

It is to be expected that the lower peats, like those of Europe, will prove to be several thousand years old and, by analysis of samples from different depths, we are attempting to follow the chemical changes which have taken place over this period especially in the production of the so-called 'humic acids', which are important agents in determining the physical and chemical properties of soils favourable for the growth of plants. Further light on the nature of these so far rather mysterious substances will, we hope, be shed by electrophoretic and spectrophotometric methods. The course of the decomposition processes is also being followed by gas-chromatographic analysis of the evolved gases. A start has been made with pollen analysis of the peats, which should throw some interesting light on the past climatic and vegetational history of the country.

In the upper few feet the course of decomposition is influenced by the activities of swampworms (*Alma* spp.) which, like their relatives the earthworms of Europe, improve the qualities of the soil for plant growth especially in increasing the quantity of inorganic ions available to plants. There are enormous numbers of these worms in the papyrus swamps of the Victoria Basin and the entire surface of the mat is often covered with their casts. They differ from the common earthworm in being adapted to life in waterlogged material devoid of oxygen. They are able to breathe atmospheric oxygen by exposing to the air at intervals the hind end, which is richly supplied with vessels containing blood with an especially high affinity for oxygen. Swampworms can only live in waterlogged conditions and are destroyed by drainage.

Exploitation of Swamps

Swamps have been successfully drained for the large-scale cultivation of sugar in Uganda, and some extensive drainage schemes have produced land for peasant agriculture and pasturage. But, apart from the cost of drainage and maintainance, it is not yet obvious that complete drainage on a large scale is in the long run the most profitable method of exploitation. It would seem on general grounds unwise to destroy by oxidation these vast stores of organic matter and put an end to the process by which they have been accumulating over centuries. It would in principle be better to exploit the swamps in their present waterlogged condition, or at least with the water-table as near the surface as possible with means for fallowing back to swamp at intervals.

There is much to be done in experimenting with techniques and crops, but a method of cultivation introduced into Ruanda-Urundi, and now spreading into western Uganda, requires no drainage and is particularly suited to the small-scale peasant agriculture which is the basis of the economy of the country. This involves clearing the swamp vegetation and piling the peat into raised beds between which are channels of open water. In these beds excellent crops of sweet-potatoes, beans, cabbages, groundnuts, etc., can be grown. There is, however, the possibility of inundation in an exceptional flood and a danger of increased transmission of malaria and bilharzia which has not yet properly been assessed. This problem is discussed below.

The cultivation of fish in dug-ponds, practised for centuries in the Far East, has recently been introduced into Uganda and is becoming very popular. The ponds can be dug into the edge of a papyrus swamp, the peat used to make the surrounding banks, and provision made for a flow-through of water. The most widely cultivated fish is the herbivorous *Tilapia zillii* which can be fed on a variety of green vegetable matter.

Papyrus is widely used for thatching and matting. It is the most prolific of all swamp plants and will regenerate in three or four months after cutting. The ancient Egyptians made their papyri by cutting strips from the central pith and hammering them together crosswise on a flat surface. The outer tissues are composed of fibres which are too short for the manufacture of modern paper, but could be used for this when mixed with a small proportion of longer fibred material. However, the difficulties of cropping papyrus on a large scale are very great and until this problem is solved there is little hope of papyrus being able to compete even locally with imported wood-pulp products. Papyrus fibre-board is being made on a small scale in Uganda.

Swamps and Human Disease

Malaria. Contrary to popular belief, the swamps of tropical Africa in their natural condition are not a potent source of human disease. Of 246 species of mosquito known in Uganda, we have found 55 breeding in swamps; the vast majority of these are culicines and do not carry malaria. The two most important malaria carriers in Africa, *Anopheles gambiae* and *A. funestus*, do not breed in the interior of swamps though they are often found in open pools, footprints, etc., around the edge. There have actually been cases in which drainage of a swamp has increased the malaria in the immediate neighbourhood. This is due to the fact that the small patches of water left after drainage, though much less extensive than the original swamps, are more suitable for the breeding of the malaria-carrying anophelines.

The factors which prevent some mosquitos and not others from breeding in swamps are of great interest. The most striking feature of swamp waters is the low concentration of dissolved oxygen (due to the processes of decomposition). The pools amongst the papyrus are often devoid of oxygen to within less than an inch of the surface for long periods. Although mosquito larvae breathe air at intervals at the surface they can also absorb dissolved oxygen, and the length of time during which a larva is submerged is influenced by the oxygen content of the water. The period of submergence is of some ecological importance and there is evidence that anaerobic conditions are unfavourable to the early larval stages of *Anopheles gambiae*. Other possible factors, which are more difficult to investigate, are those which influence the ripe female mosquito in its choice of a place to lay eggs: it is possible, for instance,

A pH meter set in dense papyrus swamp. (Photo: L. C. Beadle)

that the dense shade in the papyrus forest is a deterrent to egg laying.

The general conclusion, then, is that the swamps are not a potent source of malaria. If control of this disease were the only object it would be more profitable to preserve swamps as nearly as possible in their natural condition, and to reduce or control the breeding places around the margins. The other solution is the complete removal of all stagnant water, as has been done in the town of Kampala, but this is of course economically impossible in the country.

Bilharzia. The problem of bilharzia (schistosomiasis) is rather different. In East Africa this disease is caused by two species of the worm *Schistosoma*, which lives in the blood vessels: *S. mansoni* (causing intestinal bilharzia) is the common form in Uganda, *S. haematobium* (causing urinary bilharzia) being confined to the north and east of the country. The life cycle depends upon the eggs reaching water with human excreta, from which larvae hatch and penetrate a type of snail which is appropriate for each species of parasite. Other larvae eventually escape from the snail and can infect humans who expose their bodies to the water.

The snail, *Biomphalaria sudanica*, which can carry *Schistosoma mansoni*, is very common throughout the papyrus swamps of Uganda. It can breathe both atmospheric and dissolved oxygen and, therefore, is not affected by anaerobic conditions in the water. But since snails, unlike mosquitos, cannot move very far in a short time the foci of infection are confined to those small areas of water upon which people converge for washing, collecting water or taking to their boats for fishing. Many of the fishing villages along the west bank of the Albert Nile are almost 100 per cent infected with *S. mansoni*, which is contracted in the clearing that each village has cut through the papyrus swamp fringing the river.

Although the appropriate snails are widespread, the foci of infection are confined to very small areas of the swamps, but the problem of control in such places is extremely difficult: indeed our knowledge of bilharzia in general is as yet very much behind our understanding of malaria. Until recently little attention has been paid to bilharzia in East Africa, although both in Egypt and the Sudan and in Central and South Africa it has long been recognised as a serious problem. With the building of dams and fish ponds, and the cultivation of swamps it is not unlikely that the disease will increase in Uganda unless suitable means of control can be discovered. There is little hope of success from the application of molluscicides to patches of water which are continuous with swamps containing a vast reservoir of the vector snails. At the present time bilharzia research is being expanded in East Africa and a research unit has been set up at Mwanza, at the south end of Lake Victoria.

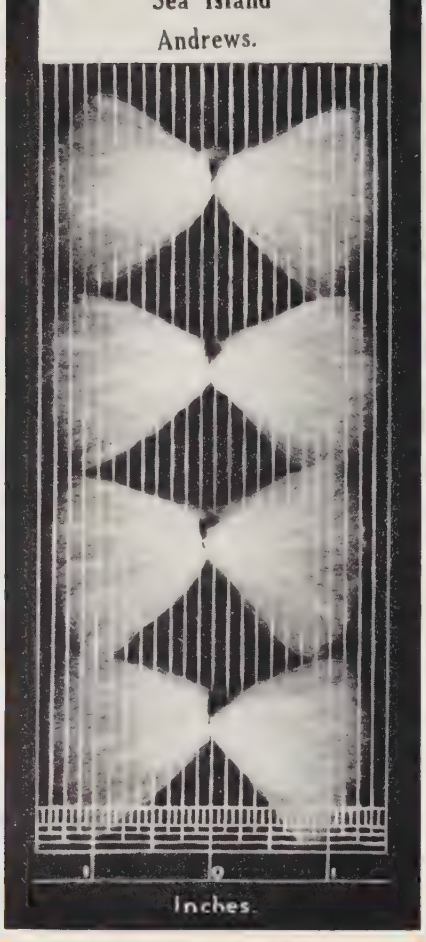
The snail, *Biomphalaria sudanica*, is also a vector of the liver and stomach flukes of cattle (*Fasciola gigantica* and *Paramphistomum* spp.) which are very common in East Africa. Cattle are not as restricted as men in their wanderings through the swamps, particularly in the dry season when in search of water and shade. The importance of swamps in the spread of these diseases has not yet been assessed, but it is no doubt considerable.

The edge of the papyrus forest. (Photo : L. C. Beadle

Cotton in India

by **B. L. Sethi,**

Indian Central Cotton Committee



Staple length of Sea Island Andrews Cotton acclimatised on the west coast of India.

Comparison between staple lengths of a typical local 'Desi' variety and an improved long staple variety.

The production of cotton textiles is India's largest single industry, and India is one of the world's biggest exporters of cotton textiles. Most of the cotton is home produced and, as the author of the following article shows, great emphasis is being placed on increasing production of the more valuable and larger staple varieties.

The first use of cotton by man is lost in the mists of time but evidence available today proves beyond doubt that fine cotton textiles were used in India as early as 3,000 years before the dawn of the Christian era. The material produced even in those remote times was so fine that, amazed at its texture, the early travellers described it as 'so fine you can hardly feel it in your hand and the thread when spun is scarcely discernible . . . when muslin is laid on the grass to bleach and dew has fallen on it it is no longer discernible'. Poetic writers went so far as to describe them as 'webs of woven wind' and many more superlatives were used in praise of Indian cotton goods.

From those days it is a long way to the modern cottons of India. The advent of the industrial revolution in Europe and the development of a world cotton industry, dependent on many sources of supply, resulted in the development of Indian varieties of cotton, which, ironically, became synonymous for short staple cottons, and India became dependent on imports for production of fine textile material.

The first attempt at the improvement of Indian cotton was made with the introduction of American cottons by the East India Company. These attempts, which were sporadic, did not meet with any success since the prevalent climatic conditions proved too harsh for the successful introduction of this cotton under rain-fed conditions. The vestiges left behind, however, gradually became acclimatised to the Indian soil-climate complex and formed the nucleus for the later development of American cottons commercially in the country.

Subsequently, systematic efforts to improve the Indian cottons were made with the establishment of State Departments of Agriculture in the first decade of this century.

Later on a committee known as the Indian Cotton Committee was appointed by the Government of India in 1919 to examine and report on the cotton-growing industry in India. This committee observed the lack of organisation of the cotton trade and of co-operation between it and the Agriculture Departments, the multiplicity of cotton varieties grown in the different tracts and many other evils impeding the progress of the Indian cotton. As a result of its findings, the Indian Cotton Committee recommended the establishment of a strong permanent committee to be known as the Central Cotton Committee, with headquarters at Bombay.

The real and effective steps towards the improvement of Indian cottons can be deemed to have been taken with the establishment of the Indian Central Cotton Committee (referred to hereafter as the Committee) in 1921. While the Committee functioned in an advisory capacity during the first two years, from 1923 onwards it was provided with funds of its own, which were liberally spent on the improvement of Indian cotton through well defined schemes sponsored in collaboration with the State Departments of Agriculture.

Varieties to Suit Conditions

The problem of cotton improvement in India is made all the more complex by the existence of a multitude of varieties. This vast sub-continent, criss-crossed with huge mountains, long rivers, fertile valleys, dense forests and arid deserts, presents a variety of climate, and the different cotton types possess special characteristics to suit these varying conditions. The cotton belt of India lies between 8° and 32° latitude North and between longitudes 68° and 82° except for a small patch of some 30,000 acres in the foothills of Assam, and it is cultivated from sea level to 3,000ft. above sea level.

The soil types range from the barren desert sandy soils of Rajasthan to the rich alluvial loams of the Indo-Gangetic plain in the north, the fertile black cotton soil of peninsular India and the red sandy loams of Madras, Andhra Pradesh and Mysore. The northern cotton areas in the Punjab experience extremes of temperature ranging from intense cold and frost in winter to summer temperatures rising to about 118°F. In the south, however, the temperature is more equable and there is hardly any cold weather. About 90 per cent of the Indian cotton crop, which covers an area of about 20 million acres, is rain fed, the annual rainfall ranging from 10in. to over 100in. These great diversities in climate, rainfall and soil conditions explain the existence of a large number of varieties of cotton in the country.

In India, all the four cultivated species of cotton, *Gossypium arboreum*, *G. herbaceum*, *G. hirsutum*, and *G. barbadense*, are grown, the last having been recently introduced. Of the six races of *Gossypium arboreum* those grown in India are *bengalense*, in north and central India, *indicum* in peninsular India and *cernuum* in the eastern region of Assam. Among the species *herbaceum*, only the race *whightianum* is grown in western India. The chief commercial cottons of India are given below:

Trade Varieties	States where Grown
Bengals	Punjab; Uttar Pradesh; Rajasthan; Bihar; Orissa.
Americans ..	Punjab; Uttar Pradesh; Rajasthan; Bombay; Madhya Pradesh; Madras; Mysore; Andhra Pradesh.
Virnar	Bombay.
Oomras	Bombay and Madhya Pradesh.
H.420	Bombay; Madhya Pradesh; Andhra Pradesh; Mysore.
Hyderabad-Gaorani	Bombay and Andhra Pradesh.
Malvi	Madhya Pradesh and Rajasthan.
Broach-Vijaya ..	Bombay.
Surti-Vijalpa ..	Bombay.
Dholleras	Bombay.
Southerns ..	Mysore; Bombay; Andhra Pradesh; Madras.
Comillas	Assam and Tripura.

In quality, the Indian cottons range from the harsh, short Comilla cottons (they are the shortest in the world) of the Assam region to the fine Madras Cambodia and Bombay American cottons. The staple length varies from about $\frac{3}{8}$in. to $1\frac{1}{16}$in.

Need for Improved Methods

The cotton cultivation practices followed in India are, as is the case with many other crops, out-moded though time-honoured, and leave very much to be desired. Though various improved methods of cultivation have been recommended by the State Departments of Agriculture, they still remain to be widely adopted by the growers; this is due to such factors as the traditional conservatism of the farmer, his economic backwardness and a lack of a full appreciation of the benefits which would result from the improved methods. Further, as mentioned already, a great bulk—about 90 per cent—of the Indian cotton crop is grown under rain-fed conditions and is dependent upon the capricious season for its success. The net result of these factors is the poor yield per acre, which is about the lowest in the world.

Of late, however, with the sustained propaganda carried on by the State Departments of Agriculture, and under the Cotton Extension Schemes sponsored by the Government of India since 1950-51, there has been a new consciousness of the need to use improved varieties, adopt improved methods of cultivation and apply more and more fertiliser in the case of irrigated and rain-fed cottons.

The use of improved seed is one of the most important single factors in any system of improved agriculture: it was in recognition of this fact that the Committee passed a resolution as early as 1929 inviting proposals from the State Governments whereby the Committee could assist (by providing staff or funds—or in any other way) in the wider distribution of the seed of improved varieties of cotton to the cultivators. As a result of this resolution, schemes for the multiplication and distribution of seed of

improved varieties, which formed a practical link between the research worker and the farmer, were sanctioned by the Committee. In recent years this work has been greatly intensified and it is estimated that as a result of work done under these schemes, and the Government cotton extension schemes, about 67 per cent, or 13.3 million acres out of the total area of about 19.9 million acres under cotton, were grown under improved varieties in 1957-58.

The improved varieties evolved have been selected not only for their superior quality, but greater yield potential, compared to the existing varieties, has also been combined in them. It may be stated without fear of contradiction that the major contribution towards the improvement in the yield of Indian cottons has been made by the breeders of improved varieties themselves, since few of the cultivation, physiological and other measures recommended have been adopted on a wide scale by the farmers. This is not to deny the value of a large amount of work conducted in India on these aspects; on the contrary, very valuable and sustained work has been undertaken in the past. But, the important results of practical value obtained have not been generally adopted as a routine by the Indian farmer, and much work remains to be done to induce farmers to adopt improved methods of cultivation.

Pests and Diseases

In the field of pests and diseases also, commendable work has been done. The major pests infesting the Indian cotton crop are jassids, aphids and bollworms, though minor pests like leaf rollers assume serious proportion in such States as Uttar Pradesh and Orissa in certain years. In the southern State of Madras the attack of stem-weevil is also a serious problem. While varieties capable of completely resisting the attack of these pests are yet to be evolved, it has been found that the incidence can be reduced through cleaner cultivation, removal of alternate host plants and the use of healthy, insect-free seed. Recently, there has been greater activity in the field of insecticide research and many new chemicals have also been discovered which are claimed to be effective. Experiments are under way in the Committee's schemes to obtain information on the efficacy of these pesticides in the control of cotton pests.

The major diseases affecting cotton in India are wilt and blackarm, while the attack of root-rot and mildew has lately shown an upward trend. In the field of diseases, the common adage, 'prevention is better than cure' is quite true. An effective insurance against disease is the evolution of a resistant variety. Fortunately, the existence of resistance genes has been discovered in the case of major diseases and work has now been in progress for several years on the breeding of resistant varieties. Most significant has been the work in progress during the last two decades at Poona on the breeding of varieties resistant to wilt. This work has paid ample dividends in that such popular resistant strains as Dig-Vijay, Vijalpa, Virnar, Daulat and Jayadhar have been evolved for the areas that were once infested with wilt. The spread of these varieties has reduced the incidence of this disease to such an extent that today wilt is not the menace it once was.

As regards blackarm, work on resistant varieties is in progress at Dharwar, in the Mysore State, and many promising types have been isolated. In almost all the schemes for breeding American cottons special attention is nowadays paid to the isolation of resistant lines. As far as root-rot is concerned a new technique has been recently devised at Poona for the artificial creation of the disease under pot-culture conditions; this is expected to help greatly in testing the resistance status of the different types to this disease in order to isolate resistant ones.

The research and development activities of the Indian Central Cotton Committee have always been planned in the larger interests of the nation by enabling the grower to earn more and more per acre and by helping the textile industry to develop through the supply of better cottons produced within the country itself.

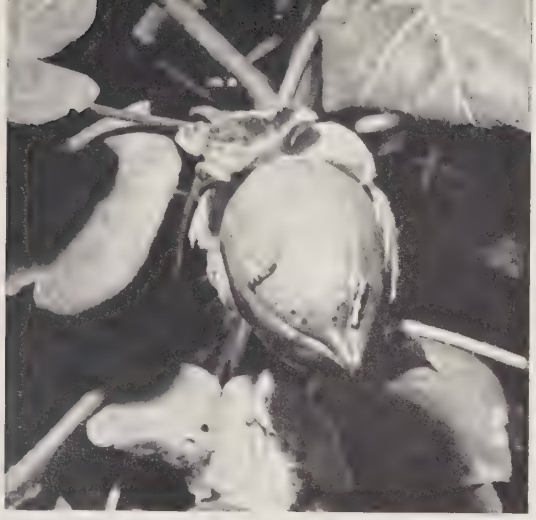
Effect of Partition

With the partition of the Indian sub-continent into India and Pakistan in August, 1947, a considerable part of the long staple cotton producing areas became part of Pakistan. In terms of figures, nearly 22 per cent of the cotton acreage, producing 38 per cent of the Indian cotton crop, seceded to Pakistan. This was further accentuated by the fact that the loss was more in the group of long staple cottons, 45 per cent of the total production of which went over to Pakistan. As against this loss in production of the raw material, 409 out of the 423 mills in India before the partition remained in the Indian Union, resulting in a critically short supply position. Because of this acute situation the Committee recommended, in 1949, that the country should become self-sufficient in supplies of cotton of staple length up to 1in. in as short a time as possible, and that the production level, then at about three million bales, should be increased to four million bales.

This was the short-term policy of the Committee immediately after partition; the long-range objective was to achieve self-sufficiency in respect of extra-long staple cottons imported then to the tune of some 700,000 bales. At this stage, the Government stepped in directly and through liberal grants from the year 1950/1951 onwards Cotton Extension Schemes were sponsored in the different States. Under these schemes, the chief measures adopted were:

(1) Expansion of the cotton area;
(2) Intensive cultivation;
(3) Organisation of cotton crop competitions; and
(4) Propaganda and technical advice to cotton growers.

The research schemes sponsored by the Committee also yielded fruitful results and many improved strains were evolved possessing better staple length and yield and other attributes, like resistance to pests and diseases and adaptability to adverse environmental factors. Of these, mention may be made of the Indo-American cottons 170-Co.2 and 134-Co.2-M of Bombay, MCU1 and MCU2 of Madras, MA5 of Mysore and more recently LL54 of Punjab, possessing a staple length of 1in. to $1\frac{3}{32}$in. The evolution and spread of these quality cottons have considerably changed the character of the Indian cotton crop



Left: *a bollworm-infested cotton plant.*

Right: *an aphid-infested cotton plant.*

as can be seen from the table below, which indicates the progressive improvement in quality.

It is gratifying that the country has now achieved self-sufficiency in cottons stapling up to $1\frac{1}{16}$in.; the present imports are confined to cottons of $1\frac{1}{16}$in. and above in staple. To produce cottons of this quality within the country itself, research activities have been recently intensified to breed varieties of $1\frac{1}{16}$in. and $1\frac{1}{8}$in. in staple. Work in this direction is in progress in the States of Punjab, Bombay and Madras and it is proposed to take it up also in Mysore. With the anticipated increase in the area under irrigated cottons on completion of the several major and minor irrigation projects (from the present level of 1.9 million acres to 3.2 million acres), and with the successful completion of research work in the schemes referred to above, it is hoped that the entire requirements of the textile industry will be met from indigenous production in the not too distant future.

Production in '000 Bales of 392lb. each

	Long Staple ($\frac{7}{8}$*in. and above*)	*Medium Staple* (*below* $\frac{7}{8}$*in. and above* $\frac{11}{16}$*in.*)	*Short Staple* ($\frac{11}{16}$*in. and below*)
After Partition (Indian Union)			
1947-48 ..	319	1,124	645
Percentage ..	15	51	34
Beginning of the First Five-Year Plan			
1951-52 ..	918	1,223	992
Percentage ..	29	39	32
End of the First Five-Year Plan			
1955-56 ..	1,577	1,781	682
Percentage ..	39	44	17
Beginning of the Second Five-Year Plan			
1956-57 ..	2,018	1,950	767
Percentage ..	43	41	16
1957-58 ..	1,982	1,926	845
Percentage ..	42	40	18

Sea-Island Cotton

This short note on Indian cotton would not be complete without reference to the Sea-Island 'Andrews' cotton which has been successfully acclimatised on the west coast of India. This cotton, which possesses a staple length $1\frac{1}{4}$in. to $1\frac{3}{8}$in. as grown in India, and was introduced from the West Indies, has been found to be the most suitable of the various varieties tested since 1949-50 under a scheme financed by the Committee. During 1956-57 it recorded high yields of over 1,500lb. of *kapas* per acre in experimental plots; in view of this the Committee decided that its cultivation should be developed in the coastal districts which receive heavy rainfall and whose warm and humid climate (almost akin to that of the West Indies) is suitable for the cultivation of Sea-Island cotton.

About 1,049 acres of Sea-Island cotton were grown during 1958-59 in the States of Kerala and Mysore, producing about 204 bales of superfine cotton. The poor yield was attributable to such factors as an unfavourable season, delayed sowing, and inexperience of the cultivators in growing cotton. It is expected that with experience better yields will be obtained. It is proposed to grow this cotton over an area of about 20,000 acres during 1959-60 and the area is planned to be extended ultimately to over 300,000 acres.

The short-term objective for cotton in India (to make good the deficit of one million bales lost on partition of the country) was achieved by the end of the first Five-Year Plan. The long-term objective is to eliminate imports. The target of production fixed for achievement by 1960-61, the end of the second Five-Year Plan is 6,500,000 bales—i.e., an increase of 53.7 per cent over the first Plan target.

The requirements of cotton depend primarily upon the requirements of cloth, based upon the *per capita* consumption. The factors next in importance are the exports of raw cotton and finished goods, the imports, and the extra-factory consumption. The target fixed for the Second Five-Year Plan is based on a *per capita* consumption of $18\frac{1}{2}$ yards, against 14 yards in the first Plan.

The title page originally designed for the first book on insects, Mouffet's Theatrum Insectorum, *which was first dedicated to Queen Elizabeth I. Publication was delayed for some years, and when the book was published it had a new title page. The original title page is attached to the manuscript, in the British Museum.*

Agricultural

by **George Ordish**

It is a constant source of annoyance to farmers, horticulturalists and gardeners that their carefully tended plants so often fall victims to attacks of pests and diseases, and it is sometimes said that we did not have these troubles in the past and only do so today because of our modern forceful agricultural methods—particularly the use of fertilisers, pesticides and so forth.

There are two statements here that need examining: this is not the place to enter the controversy the second sometimes causes, but the first warrants attention for it is quite wrong. Our forefathers' agriculture certainly suffered considerable, even disastrous, losses from numerous pests, as can be seen if one looks into the records. I think the reasons for supposing they were free from these troubles are firstly a general nostalgia, in this mechanical age, for a past rural utopia, which in fact has never existed outside the Garden of Eden; secondly, that so often in the past these attacks were taken for granted and not much was said about them; and thirdly, the matter has been but little studied.

When one does look into the history of pests one does find references to these losses and to many remedies being suggested for overcoming them. Some of these I mention below.

Much of our knowledge of the agriculture of the ancient world comes from Pliny's *Natural History*. This curious and indefatigable author perished in the eruption of Vesuvius in A.D. 79, after having compiled his vast pandect in some 31 books. Reviled today as a 'scissors and paste' man, Pliny yet had much original thought (for instance, he deduced from the evidence that the world was round and rotating at an 'incredible speed') and he has much to say on the pests of crops. Large parts of Books 17 and 18 deal with this subject and nothing else.

First of all there is the general observation 'For even trees are liable to attacks of disease, since what created object is exempt from these evils'?* One can recognise a number of caterpillar pests from Pliny's descriptions, such as the winter moth, ermine moth, codling moth, black-veined white (now extinct in Britain) and so on. The Cossus, or goat moth, though a pest of trees was also a

*Infestantur namque et arbores morbis—quid enim genitum caret his malis. Lib. XVII. cap. xxxvii. 216.

Pests in History

table delicacy (as are Agave caterpillars today in Mexico). 'Worms' troubled the olives, and the olive fly, *Dacus oleae*, still causes great losses in the groves. Cereals were by no means exempt from troubles and rust was a constant threat; the alternative host for rust is the barbery, and although Pliny can have had no conception of the nature of a fungus disease he did notice that rust was worse where the barbery flourished.

The vegetable garden was not immune for they ' . . . are also liable to disease, like the rest of the plants on earth'. 'Springtails', that is the fleabeetle or fly attacking the turnips, caterpillars the cabbages, and the maggots in the radishes were no doubt then, as now, larvae of the cabbage fly.

The ancients did not accept these troubles passively but took active steps to overcome them, using religious, superstitious and practical measures, these last falling into the familiar three classes of mechanical, biological and chemical methods. The remedies may not seem very effective to us, but they did do something about it, which was always the Roman attitude to difficulties. Rust seems to have been a very old trouble and a special religious ceremony was held on 25th April—the *Robigalia*—at the second milestone on the Via Claudia to propitiate the god and secure good crops. This was said to have been instituted by Numa, the legendary second king of Rome, in the eighth century B.C. At the same time mechanical and biological methods were being advocated, such as growing wheat only for the house and barley for the animals, as the latter was less susceptible to rust, and avoiding the Achilles barley as it succumbed to the disease easily.

Locusts

Locusts were always a threat; the world being so much less densely populated there were many areas where swarms could build up unseen and unknown. Laws were passed dealing with these pests; at Lemnos, for instance, each freeman was obliged to return to the authorities a certain weight of locust eggs, adults or hoppers during an attack.

The success of the Roman Empire depended on the organisation of supplies; large quantities of food had to be delivered to the cities and armies with very limited means of transport, so the interest in securing good crops was real; avoidable losses could not be afforded, hence also the interest in all methods of pest control. The Romans even used sprays of a sort—a decoction of wormwood or houseleek, for instance, was said to kill cabbage caterpillars; seed dressing with ashes, or soda and oil dregs was advocated, and the use of banding grease (oil leas, bitumen and sulphur boiled together—in the open air, because of the risk of fire) was advised for keeping certain pests off vines and trees. These are not very effective remedies, but they are on the right lines and the fact that they are advocated shows that the pests were indeed present.

There is also in Pliny a forecast of some modern methods of bird pest control. One method was to put out a narcotic mixture, made by boiling alum and garlic; the birds were said to feed on this and fall into a stupor—though one doubts if they really would. A narcotic is used in France today for controlling harmful birds; the useful ones are allowed to recover, the pests being destroyed while they are insensible.

When we come to the Middle Ages we find a greater preoccupation with the pests of humans and animals than of crops, and we see that constant resource was being had to the authority of the classical writers. Thus, if Pliny said that two crabs put in a pot and buried in a field would keep it free of caterpillars, then it must be so.

In a fifteenth-century picture book of animals, the *Hortus Sanitatus*, we find a number of pests depicted, such as fleas, lice, tapeworm, flies on meat, and wasps. We can see a head being vigorously brushed to remove lice and a number of decoctions are suggested as remedies, such as a mixture of old butter and mercury: one wonders if the old butter would not have been as unpleasant as the lice themselves!

With Francis Bacon and the rise of Baconism we get a change of attitude: the philosopher was now called upon to collect evidence and facts and to make experiments before pronouncing judgement; nor must he bluntly accept authority. The sixteenth century saw the rise of the naturalists, the men who studied the life of the world around them for its own sake rather than for any practical end. Reading their works we can see that the farmers did have pests.

First Insect Book

We now come to the first book on insects. It is a remarkable work called the *Theatre of Insects* (*Theatrum Insectorum*), which in describing these creatures notes many

(*continued on page 26*)

The lucerne butterfly, Colias lesbia.

The common wasp, Vespula vulgaris.

About 1550 Thomas Penny prepared a number of coloured drawings of insects; these drawings are stuck to the manuscript of Mouffet's *Theatrum Insectorum*. Some are reproduced here by permission of the Keeper of Manuscripts, British Museum.

A bush cricket, identified by Bodenheimer[1] *as* Tettigonia viridissima. *This insect is closely related to the grasshopper.*

A beetle, identified by Bodenheimer[1] *as* Carabus auratus.

The swallowtail butterfly Papilio *sp.*

mole cricket, Gryllotalpa
yllotalpa.

[1] *Materalien zur Geschichte der Entomologie*, F. S. Bodenheimer: Junk, Berlin, 1929.

(*continued from page 23*)

that were pests. Although this was the first book to be written about insects it was not the first published, owing to many delays. The authors were Conrad Gesner, of Zurich, and three Englishmen, Edward Wooton, Thomas Penny and Thomas Mouffet (or Muffet). The manuscript of this book, now in the British Museum, has many remarkable water-colour drawings stuck to it, which formed the basis of the woodcuts in the book. The drawings are both beautiful and accurate. Ready in 1589, the book was dedicated to Queen Elizabeth, but it was not published until 1634, being rededicated in the meantime to James I, though all the authors were dead by then, and the king, too. It was written in Latin, the universal language of scientist and philosopher of that day.

Many pests are shown in *Theatrum Insectorum*, such as the cabbage white, the winter moth, the gipsy moth and others. There is an account of what must have been an enormous invasion of maybugs, or cockchafers, for they were so numerous that they choked the waterwheels in the Severn and caused a bread shortage. We certainly see nothing like that today, though maybugs can still be a severe pest in parts of Europe. Mouffet *et al.* made an important observation—that insects came from eggs; nevertheless they still seemed to believe that 'corruption' bred them as well, and this belief in the spontaneous generation of life, in spite of William Harvey's *omnia vivum ex ovo*, persisted down to the time of Pasteur.

The *Philosophical Transactions of the Royal Society* of the seventeenth century contain a number of important observations on pests—even one from New England about an insect (obviously the seven-year locust) destroying trees and crops. There are accounts of locust invasions of Ireland and Wales (which we no longer see) and of codling moth in apples, to mention a few. Leeuwenhoek, the inventor of the microscope, reports on the parasitising of aphids and on how these insects bring forth living young.

Plant Diseases

The seventeenth- and eighteenth-century 'philosophers' found insects more easy to understand than diseases: the insect eat the plant and if it was killed this plant was saved. Diseases were more mysterious and philosophy was long away from the truth. From early times diseases caused trouble in grain. The Romans suffered from rust and northern Europe had trouble with bunts. The bunt balls, the masses of black fungus spores ground with the sound kernels, gave a detested, violet-coloured, fishy tasting flour: one of the reasons for the popularity of gingerbread was that it disguised both these defects. Ergot of rye was more serious and produced chronic poisoning in the Middle Ages. The black horn-like ergots were again ground with the grain and had grievous effects on those who ate the resulting bread, causing abortions and irritation in the extremities—and even their loss. The sufferers stamped their feet and swung their arms about, and the waves of dancing madness are thought to have been due to chronic ergotism.

In the eighteenth century, bunt was so prevalent in France that the Académie des Sciences de Bordeaux, in 1750 offered a large prize for the best essay on the subject. It was won by a M. Tillet, who was the master of the mint at Troyes. Determined to find out what caused the disease and how to cure it, he conducted a series of small plot experiments, which would not disgrace a modern research station. Was it from the air—a miasma—from the dung, from sheep, from old seed, from the black dust, perhaps? Tillet proved triumphantly that it was this last, and that seed dressing with lime and salt would cure it. Tillet prided himself on being a practical man, and refused to indulge in 'philosophical speculations' as to the root causes of the trouble: this was unfortunate, for he had already noted that the dust was not unlike puffball dust and, with such an enquiring mind, had he speculated he would have soon realised that the disease was a fungus. This would have advanced agricultural science by a hundred years at least, and very likely the outbreak of the potato blight in Ireland would not have resulted in famine, had it been known for a hundred years that plant diseases were so often caused by fungi. When bunt was finally traced by the Tulasne brothers they called the fungus *Tilletia* in honour of this famous experimenter.

As international intercourse increased, particularly across the Atlantic, plants were moved around and pests and diseases released in new territories, or plants introduced into new environments were attacked vigorously by indigenous pests. Not that this had not happened before, for that great gourmet, Lucullus, brought back the cherry from Cerasus as one of the spoils of his campaign against Mithradites, and was annoyed when the Italian maybugs attacked it severely.

Vines in Europe were seriously incommoded by these exchanges; in 1845 the Royal grapes at Versailles were attacked by the powdery mildew from America; by 1852 a M. Grison had invented the cure, lime sulphur; this liquid was at first called *Eau Grison*. Next, the phylloxera and downy mildew attacked the vines—stories so well known as to need no repeating. For the same reason one forbears to say much about the Irish potato blight—and in any case its study is now in the excellent hands of Miss Cecil Woodham-Smith. Blight is a disease which, a century ago, devastated a country, caused a million people to emigrate and about a million to die of hunger, and one which had far-reaching political consequences. Today it is well controlled; it broke out, it may be noted, long before 'modern' agriculture was adopted.

These are just some of the outstanding events of interest in the history of pests; a great deal more has been found in the literature and further study is likely to uncover additional items. As this article started with a reference to Pliny it does not come amiss for it close with him, and we would do well to bear his advice in mind (it is still the advice of all good agronomists): 'But it is of the first importance to avoid allowing our remedies to produce other defects, which result from using remedial processes to excess, or at the wrong time. To prune away branches is beneficial to trees, but to slaughter them every year without respite is extremely unprofitable'.

SPECIFICATIONS — THE GUARANTEE BEHIND QUALITY

To anybody who is called upon to order formulated agricultural chemicals the subject of specifications is an important one. In the following article the author sets out to explain the requirements of a good specification. What should it contain? What should it omit? In a later article Dr. Gill will show how the basic principles outlined here can be applied to specific formulations.

by **R. E. Gill,** B.Sc., Ph.D.

Shell International Chemical Company.

One may distinguish, within the agricultural chemicals industry, between those whose business is to produce agricultural chemicals in the form of technical insecticides, fungicides, etc., and the 'formulator', whose business is to convert the agricultural chemical into a form which is suitable for use in the field. Both these operations may, of course, be carried out by the same organisation.

In the majority of cases, the agricultural chemical is supplied to the farmer (or other user) after it has been formulated. This is necessary because most of the chemicals are effective biologically in very small quantities and it is physically impossible to spread uniformly a small amount of any material over a very large area, e.g. 2oz. per acre. In order to overcome this problem, the chemical must be diluted considerably. The various physical and chemical processes involved in doing this are collectively known as 'formulation'. The final products are variously referred to as 'formulated agricultural chemicals', or as 'agricultural formulations' or, simply, as 'formulations'. It is not intended to imply that formulation involves only a simple process of dilution. Whilst this may be an approximation to the truth in a few instances, formulation generally involves a complexity of considerations which for years have defied the efforts of the formulation chemists. In consequence, poor quality formulations have appeared on the market and many users are aware of this.

Any given agricultural chemical may be presented to the user in a variety of forms or formulations; these commonly include:

1. Dilute solutions—suitable for use directly;
2. Concentrated solutions—which may be used directly or after dilution with a petroleum solvent;
3. Emulsifiable concentrates—for dilution with water before use;
4. Wettable powders—for dilution with water before use;
5. Dust concentrates—for dilution (in a formulation plant) to field strength dusts;
6. Field strength dusts—ready for use;
7. Granules—ready for use.

Why Specifications?

Before an agricultural formulation is offered for sale, the formulator has to carry out a great deal of research and development work, but none of this will be of any avail unless he can persuade his customers that his products are of good quality. How is this to be done? A partial answer is certainly that the formulator should apply to all his formulated products specifications which will provide the user with a reasonable guarantee of their reliability and with confidence in the formulator's abilities.

Part of the answer to the question may also be to advertise the quality of the products, but in the long run the best advertisement will be the goodwill built up over the years, which results from the customers' confidence in the manufacturer's products. This confidence will depend on good quality, and this, in turn, will depend on the existence of specifications which have been drawn up realistically and intelligently. The continued introduction in recent years of new agricultural chemicals has, in fact, been accompanied by an increasing appreciation of the value of specifications which may relate to the chemicals themselves or to the formulated products containing them.

Before considering the requirements which may justifiably be included or excluded from a particular specification, let it be supposed that agricultural formulations were to be sold or purchased in the absence of a specification. Such a situation would not be welcomed by the supplier who values his good name, because he will always be anxious to provide his customers with any reasonable guarantees concerning the composition and properties of his formulations and he would, in fact, prefer the customer to be in a position, should the occasion arise, to make any justifiable complaint concerning the products. Only in this way is satisfaction assured on both sides.

In the absence of a specification, the purchaser is, of course, in an intolerable position. He may order and obtain supplies of a wettable powder having indifferent

wetting or suspension properties which could deteriorate rapidly during shipment—in which event, subsequent spraying operations could be carried out leaving the majority of the insecticide in the spray tank. He could obtain supplies of an emulsifiable concentrate which, though emulsifiable, would give an extremely unstable emulsion likely to cause much damage to crop plants owing to the occasional spraying of 'neat' oil. He may purchase a field strength dust for application to foliage which, because of its high bulk density, may be unsuitable for that purpose (although it may, possibly, be suitable for application to the soil). He may obtain a liquid product containing less than the expected amount of insecticide, or one from which a proportion of the insecticide has crystallised out forming a hard mass at the bottom of the container. In these ways and others, he will have good cause to be dissatisfied.

Clearly, the wise manufacturer of formulated products will wish to ensure that his products are of a high standard of quality and the standard which he sets for himself may well exceed the standard laid down by national or international organisations or by individual customers. Otherwise stated, the manufacturer will probably use 'manufacturing specifications' to ensure that each batch of product conforms with the standards set by himself. In all probability, these specifications will be more stringent in their requirements than the specifications likely to be insisted upon by the customer. In this way, the manufacturer provides himself with a 'safety margin'. The manufacturing specifications represent, in a way, the culmination of the research and development work, including field tests and trial marketing, which precede the commercial introduction of the formulations. The value of these specifications, both to the manufacturer and to the purchaser, is clear and one may now consider the precise form which such specifications should take.

What Should be Specified?

In a broad sense, a specification for an agricultural formulation may be regarded as a guarantee to the user of product quality and performance. The specification will normally consist of a number of clauses, each of which sets a maximum and/or minimum limit to some physical or chemical characteristic. These include the percentage of active ingredient(s); the particle size (of solid formulations); the suspension properties (of wettable powders); and the emulsion characteristics (of pre-formed emulsions or of emulsifiable concentrates).

It is easily possible to extend such a list of characteristics, but it should not be assumed that this is necessarily desirable. In compiling a specification relating to any particular formulation, there are several important principles which should be observed. In the first place, for example, one has to decide which of the properties of the product are likely to be of importance in practice. In the case of a wettable powder, the most important physical property will be its suspension characteristics; if these are inadequate, the performance of the product will be correspondingly poor. The principle involved, therefore, is that the specification should govern the performance of the product rather than its chemical composition.

Having decided on those properties which are important, one then has to consider which of them can be measured realistically, and it will be important to exclude from the specification references to any which cannot be assessed quantitatively in the laboratory. The specification will now contain a number of clauses, each of which relates to a property having real practical significance which can be measured with some reasonable degree of accuracy. The next problem is to decide on the precise limits which should be set in the specification in relation to each of the properties concerned. Whilst in many cases maximum *or* minimum limits may be most appropriate, there are occasions when it may be desirable to specify maximum *and* minimum limits for a particular property. It is also possible to set a limit which is either too 'high' or too 'low', having regard to the purpose for which the product is to be used. One may specify, for example, that an emulsion shall remain stable for some days and, although the formulator would no doubt find it possible to prepare a product in line with such a requirement, it may be found in practice that a less stable emulsion would be more suitable.

It has already been established that the specification will contain clauses relating only to those properties which can adequately be measured. It follows then that the specification must contain, or make reference to, precise and detailed descriptions of the way in which each property has to be measured. Many standard test methods are described in the literature, which makes it possible to refer in the specification to the appropriate published method. Sometimes various modifications of what is nominally the same method are referred to in the literature, and these modified methods would in all probability give different results. Clearly, therefore, the specification must refer either to a fully standardised procedure which has been published, or the specification must itself contain precise details of each method which is to be used to measure the property concerned.

While the manufacturer may possess specialised laboratory equipment which enables him to perform certain complex analytical procedures or test methods, it is nevertheless desirable in a specification that the methods prescribed should involve the use of relatively simple laboratory apparatus. The all-important principle is to use test methods which are as simple as possible, which give repeatable results and which will serve to give a reliable indication of the performance of the product under field conditions. Nevertheless, one has to recognise that many relatively complex organic compounds are now used as agricultural chemicals and these compounds cannot in many cases be identified by any simple chemical analytical technique. In such circumstances, the manufacturer will probably employ a physical method such as infra-red spectrophotometry, because this may provide the only means of identifying the compound.

For routine control purposes, however, the manufacturer or the customer may well decide to use a simple chemical

method, recognising that this cannot identify the compound concerned and cannot therefore be used to provide proof of its presence. This point is well illustrated by the widespread use which is made of various methods which depend on the determination of the amount of organic chlorine. These methods are used to estimate indirectly the percentage of chlorinated insecticides, such as DDT or dieldrin, in samples of formulated products containing these insecticides, whereas the identification of an insecticide such as dieldrin can only be accomplished using an infra-red spectrophotometric method. A practical answer to this type of problem is to use the non-specific chemical method for all routine purposes, but to rely on the specific method to settle any dispute which may arise.

Those concerned with the compilation of specifications recognise very well the importance of applying a tolerance to each of the physical test methods or analytical methods which form part of the specification. If such tolerances are not given, the analyst is in no position to decide whether a given sample should be accepted or rejected in cases where 'border-line' figures are obtained. Disputes are likely to arise whenever the purchaser or the supplier has failed to understand the importance of this question. However, as it involves a number of complexities, it is not proposed to discuss this question further in this article.

What Should be Omitted?

In contrast to the advice given above, it is not uncommon to find in purchasers' specifications clauses governing properties which cannot adequately be measured. An example is the so-called 'sticking' properties of solutions or emulsions. Any formulator whose products are backed by a research organisation will, of course, recognise that a relation exists between the biological properties of his products and properties such as their surface tension, which will influence the extent to which the product will adhere to foliage. He will also know that different effects are obtained using the same product under the same conditions on different types of foliage. The measurement of properties such as surface tension is possible under carefully controlled laboratory conditions and useful comparative data may be obtained in this way. On the other hand, insufficient is known about the relationship between surface tension and adhesiveness to warrant the inclusion in a specification of clauses governing any such properties.

Examples of other properties which should not be included in specifications because they cannot be measured absolutely are the clarity of liquid formulations, the flowability of solid formulations and the 'wetting properties' of liquids or of wettable powders. It is similarly of little value to specify that a product shall have 'good storage stability', nor would it be realistic to require that the product shall retain its properties unimpaired after storage for, say, two years. There are tests which can be used to simulate prolonged storage and the reputable formulator can be relied upon to make use of such tests. He cannot, however, be expected to make guarantees concerning the useful life of his products when this is dependent on factors beyond his control. If formulations which are sensitive to high temperatures are stored in the vicinity of ships' boilers or in drums exposed to direct sunlight, it is to be expected that deterioration of the product will occur, but it hardly seems reasonable to expect that the formulator should be held responsible.

The specification should not be worded so as to preclude the manufacturer from choosing certain ingredients, such as carriers and emulsifiers which he prefers to include in his products. In the case of solid products, for example, the formulator is best able to decide which carriers are most suitable and he knows how these carriers can be effectively deactivated, if necessary. Similarly, where liquid products are involved, the choice of solvents and emulsifiers will be based on the manufacturer's experience, which will include knowledge of the phytotoxicity of the finished product when this is applied at the correct dosage rates to the crops on which it is to be used. He will know, therefore, that the products which he offers will be 'safe' for the purposes which he recommends, but he cannot normally be expected to include in his specification any clauses which refer specifically to biological properties. Such clauses would involve the repetition of biological tests and this would increase the price of the product inordinately. Equally, it may not be reasonable, in the case of liquid products, to specify the specific gravity or the volatility of the solvent or of the finished product, because this would restrict the manufacturer in his choice of solvent and it might preclude him from using a solvent which he knew to have certain preferred properties.

To summarise, a specification can be valuable both to the producer and the purchaser, but it can also be a source of difficulty unless certain rules are observed. In general, the specification should refer only to those physical and chemical properties (but not the biological properties) which are of real practical significance. These properties must be measurable (directly or indirectly), preferably by a relatively simple method of test or analysis which is described in concise and unambiguous terms. The limits which are set in the specification should be related to practice as far as possible. The specification will refer to the required minimum percentage of the active ingredient, but it should not generally refer to the identity or quantity of the other ingredients present.

The advice given here to purchasers of agricultural formulations is that they should obtain their supplies against their own specifications or against some existing standard specifications (provided that these specifications adequately cover all the requirements) or that they should invite the supplier to provide details of the specification against which he is prepared to sell and guarantee his product. In the long run, the product which gives the most satisfaction will not necessarily be the cheapest product nor the most expensive one. It is more likely to be the product supplied by the experienced formulator, backed by research facilities, who is able to provide a firm specification and is nevertheless willing to rectify the mistakes which are inevitably made on rare occasions even in the best regulated formulation plants.

Estimating Residual Insecticides on Wall Surfaces

by **A. V. de Courcy**

Shell International Chemical Company.

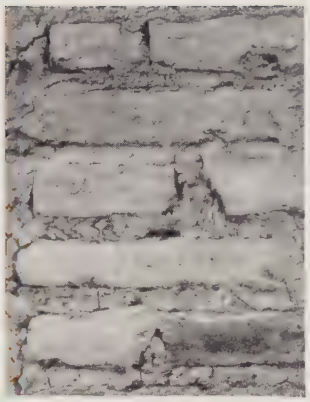
A mosquito trap; there are four such traps in the walls of this house.

Control of insect-borne diseases by spraying residual insecticides on wall surfaces with which the vectors come into contact is a subject of major importance in many countries. For several reasons a method for determining insecticide deposits on wall surfaces during such work is required. First, it is often necessary to establish that the spraying equipment and technique selected will result in the intended deposit of insecticide being left on the wall; secondly, it may be necessary to check that spray operators ('spray-men') are doing their work thoroughly—by sampling sprayed surfaces soon after spraying has been completed; and thirdly, the persistence of an insecticide deposit over a period of time may need to be established.

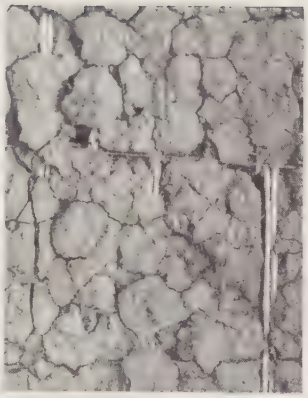
Commonsense dictates that whatever the reason for sampling, any previous history of insecticide spraying should be known to enable the analytical results to be interpreted correctly. Control samples taken before spraying must necessarily also be analysed, whether or not spraying has been carried out before, as one or more components of the sprayed wall may produce positive results in the analytical method chosen. When taking control or actual samples, the possibility of old spray residues varying in extent at different points in the wall is very real. Such variations can occur through the position of furniture and pictures being changed or through physical removal by people rubbing against the wall; this is especially likely to occur near doors. Sampling should therefore be replicated to an extent where the average of all sample results remains constant, even with increasing replication.

The choice of analytical method is outside the scope of this article but it may be mentioned that as most public health insecticides are chlorinated hydrocarbon compounds

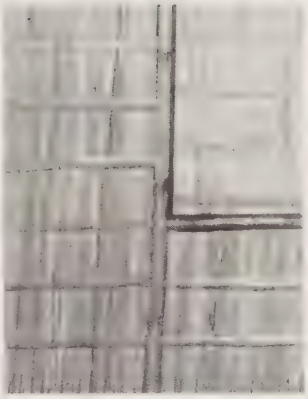
Four types of wall surface which illustrate the difficulty of representative sampling, as insecticide deposits are likely to vary from one point to another on the same wall.



1. A mud brick wall.



2. Mud plastered on bamboo.



3. Leaves of Nipa fruticans *used for building.*

4. The upper part of thi wall is of bamboo.

the total chlorine method is probably most widely used. This method can be quite reliable, but is only so when a control, or blank value, has been derived for deduction from the results obtained with treated samples.

Several techniques have been proposed by which one or all of these requirements may be met; let us consider each requirement separately.

Suitability of Application Technique

Losses of insecticide caused by run-off, rebound from the sprayed surface, and failure of small droplets to reach the sprayed surface, together always result in the efficiency of a spraying process being below 100 per cent. A method is therefore necessary to establish the actual efficiency achieved. This is calculated as:

$$\frac{\textit{amount of insecticide deposited on wall}}{\textit{amount of insecticide discharged at the nozzle}} \times 100$$

That it is important to investigate this subject fully has been shown by several workers (1), who have demonstrated that the efficiency achieved varies with the nature—particularly the absorbency—of the surface, the formulation, the spray pressure, the type and size of nozzle and the distance this is held from the surface. To obtain the best possible compromise between these variables, trials must be arranged to determine the variations in efficiency produced by different sets of conditions. Further points to be borne in mind are that the more efficient the spray process, the less the spray-men are likely to be contaminated by the insecticide and the smaller the wastage of insecticide; over the whole of a country-wide programme this latter may be a very material point.

Perhaps the most commonly used method for checking the quantity of insecticide deposit on a wall surface is to pin filter papers to the walls being sprayed, and after spraying to analyse them for insecticide content. This method is open to the objection that the spray-men may deliberately treat the papers more thoroughly than the rest of the wall surface, but where the theoretical efficiency of the spray process is being completely investigated it should be possible to resist this temptation. A more real objection to the method is that a filter paper provides a type of surface which may be very different from the surfaces to be sprayed in the field. As shown by Wolfe *et al.* (1) a change in surface caused by spraying a room several times without cleaning the sprayed surfaces, so that a heavy residual deposit is built up, can result in a considerable increase in the efficiency of the spraying process.

Alternative methods aim either at obtaining an actual sample of the sprayed wall surface, or are designed to enable a visible estimation to be made of the amount applied, by including indicators such as dye stuffs in the spray mix. Unfortunately the concentration of dye required, or, in the case of other indicators such as powdered aluminium, the economics of the method, make such alternatives unacceptable.

When considering the suitability of a spray technique one is not interested in knowing the amount of insecticide which will affect an insect alighting on the sprayed surface, but only in the amount of insecticide which has been applied to the surface. This means that any method chosen for investigating the suitability of an application technique need not be so delicate as to remove only the surface deposit, but can remove, say, the top 1mm. of the wall. It is unlikely that the insecticide will have migrated by absorption or diffusion more than this distance into the wall during the short time which will have elapsed between spraying and sampling. Various simple devices can be employed for removing such a superficial layer from the wall over a given area.

Where the sprayed surface is impermeable the deposit may be sampled by swabbing with wadding soaked in a suitable solvent. Special difficulties occur where irregular surfaces, such as those of bamboo, maize stalks or reeds are to be sampled. In such cases the only method of sampling is to remove part of the fabric of the wall for examination in the laboratory.

Checking the Spray-man's Work

The problem of discovering whether spraying has been properly carried out has much in common with that of

deciding on the suitability of the technique. Comments on the use of filter papers apply with even greater force as there is always the possibility that these will be given preferential treatment by the spray-men.

Although with experience it may be possible to assess visually (e.g. by running a finger over the surface) whether sufficient insecticide has been applied, such an approach is only possible with impermeable surfaces. On mud walls sampling and subsequent analysis is the only practical answer, and this method is therefore to be recommended. The procedure for doing this has already been discussed, but a further important point is that spray-men frequently give greatest attention to the part of the wall at elbow height, so that when sampling particular attention should be paid to heights above and below this level. It is naturally of prime importance to obtain control samples just before the spraying operation under investigation.

Persistence of Deposit

Investigation of the question of persistence has resulted in many erroneous and irrelevant findings being recorded in the literature. The only question of practical interest is how much insecticide is potentially effective to an insect coming into contact with the treated surface. This has been realised by the proponents of most methods of investigating the subject, but it has not always been realised that the amount of insecticide available to the insect at any one point can vary at different times according to environmental conditions.

For example, it has been shown that humidity is an important factor dictating the availability of insecticide applied to various mud surfaces (HADAWAY and BARLOW (2, 3) and recent unpublished work by Woodstock Agricultural Research Centre, 'Shell' Research Ltd.). Thus, in the case of many tropical muds dieldrin is absorbed below the surface when the relative humidity falls below 60 per cent, but it is released at the surface when the relative humidity rises above this figure once more.

Surface irregularities also make it impossible to remove by any sampling method only that part of the surface with which an insect might come into contact. For this reason methods attempting to do this using adhesive tape, carboxy methyl cellulose films and various plastic adhesives, although perhaps approaching the end in view, are not acceptable. It would seem far better to employ the insect itself as the sampling agent—i.e., to use a form of bioassay.

Limitations of Bioassay

All the bioassay methods in use have their limitations. Enclosure of insects on a surface in petri dishes, for example, is a completely artificial test. Such a test deprives the insect of any choice of location and ignores any irritant effect the insecticide may have. At the same time, the flow of air across the surface is restricted, thereby perhaps increasing any vapour effect of the insecticide. Any such artificial method of bioassay is prone to error and may ignore such a question as, for example, the length of time for which the insect should be exposed, the time of the day at which it should be exposed and the effect of the age and state of nutrition of the insect.

If, then, it is agreed that such factors should not be ignored there is only one course available, namely to test the effectiveness of the insecticide deposit under the conditions under which the insecticide is required to act. To do this may require the services of experienced personnel who may often not be available, and it may be more time-consuming and require more equipment than testing under artificial conditions. But the results obtained will be capable of interpretation.

An example of such an approach is the use of houses fitted with window traps at night to assess the percentage mortality of mosquitoes after residual spraying of house interiors. Mosquitoes are able to enter through the wide funnel openings of the traps but are unable to leave via the narrow opening on the inside. A human sleeping in the house at night acts as bait. The following day, when any mosquitoes which are still alive try to leave the house,they are caught in the traps and retained for some hours, enabling delayed mortality to be observed. Efficiency of the insecticide deposit is then calculated as:

$$\frac{\textit{total dead within the house and window traps}}{\textit{total dead within the house and window traps} + \textit{total alive in window traps.}}$$

A further refinement of the method is the use of a pyrethrin spray in the house after making the final counts to check that all living mosquitoes have entered the traps. Such a method can provide valuable additional information. For example, the resting habits of the vector may have changed so that resting occurs on parts of the house structure or furniture not previously sprayed; this will result in a lower percentage mortality being achieved. Such possibilities must be excluded before low mortalities are ascribed to poor residual properties of the insecticide. A further point of importance is that often, because apparently good control of a vector has been shown by tests such as the above, it is assumed that control or eradication of the disease will follow. This is not necessarily so. The only reliable indication of the success of an insect vector control programme is the decline in incidence of the disease itself, as measured by medical statistics.

While, therefore, one must condemn many of the practices which have been in widespread use without being able to offer convenient alternatives, one must also recognise that under some conditions established sampling techniques have their uses; but as they also have their limitations, results obtained from their use should be interpreted with discretion.

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Field Resistance to Organo-Phosphorus Insecticides Reviewed

The following review of the known field occurrences of strains of pests resistant to organo-phosphorus insecticides indicates that the emergence and spread of such strains has not progressed in a significantly different manner from that of strains resistant to chlorinated hydrocarbon insecticides. A total of 18 pest species have shown resistance to no fewer than 26 organo-phosphorus compounds. In most cases, certain compounds have had to be dropped from control programmes. In some instances other organo-phosphorus compounds have remained effective, while in others control has had to be obtained with chemicals of other groups.

The emergence of resistant strains is most acute as a practical problem among the mites, but once again the house fly is proving a resilient and adaptable pest, and the recently adopted control measures involving organo-phosphorus insecticides are already in jeopardy, at least in certain areas.

by **J. C. Felton**

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As an increasing number of pest species of insects and mites have developed resistance to chlorinated hydrocarbon insecticides, and to some other erstwhile standard control chemicals, the solution to many pest problems has been increasingly sought among the organo-phosphorus insecticides (OPs). It had been hoped that resistance to this group of compounds was inherently less likely to occur in pest species. This review was undertaken to determine to what extent actual field experience would seem to justify this view, and to ascertain the extent to which resistance to OPs is already present in the field, and invalidating control measures utilising these insecticides.

Table I summarises the literature references to strains resistant to OPs. Only those instances where strains have developed under field conditions are included, together with any laboratory results on such wild caught resistant strains. No account is taken of strains artificially developed under laboratory conditions. It will be seen that 18 pest species are involved, and resistance has been shown to 26 OPs. It is noteworthy that all except two of the species have shown resistance to parathion, almost certainly the most widely used OP insecticide. Resistance is also often developed to malathion, demeton and trithion, the former two also being widely used insecticides. *Paratetranychus citri* has shown resistance to 15 OPs, *Tetranychus telarius* and *Musca domestica* to 10. In all, 73 resistant species/chemical combinations are listed, of which 41 refer to mites.

Mites

The earliest record of field resistance to an OP would appear to be that reported on by SMITH and FULTON (28), who recorded three strains of *Tetranychus telarius* resistant to parathion collected in 1948-1949 from Cranbury, New Jersey, and Bloomsbury and North Wales, Pennsylvania, though during 1949 further resistant strains of the same species were reported from Urbana, Illinois (7), Cromwell, Connecticut (10) and S. California (13), and in 1951 from Norway (9). Little evidence is available on resistance factors by laboratory test methods, but GARMAN (10) gives a factor of more than X8 to parathion for one strain. One strain, as well as being resistant to parathion, showed resistance to paraoxon, methyl parathion, O-ethyl O,O-bis (p-nitrophenyl) phosphorothionate, TEPP, T isopropyl PP and dithion. However, dithion was able to effect control in the field, as was Schradan (28). GARMAN (10) reported that TEPP and dithion were effective in the field, while FJELDDALEN and DAVIKNES (9) found Schradan, demeton and dithion effective, but EPN ineffective, and they suspected resistance.

Resistance to OPs was early reported in *Metatetranychus ulmi* by O'NEILL and HANTSBARGER (25), a population resistant to several OPs being found in the Wenatchee Valley, Washington, in 1950. NEWCOMER and DEAN (24) reported parathion resistance in this species from the Yakima Valley, Washington, in 1951, and parathion resistance was also reported in 1952 from New Paltz, New York (20) and Clyde, Ohio (5), in 1953 from British Columbia (23) and in 1955 from Switzerland (31). In British Columbia, the rust mite, *Vasates schlechtendali*,

also showed resistance, with the possibility that a predacious mite, *Typhlodromus occidentalis*, was at least inherently tolerant, if not also resistant. No information appears to be available on the determination of resistance factors by laboratory methods for *M. ulmi*. The strain reported by NEWCOMER and DEAN (24) proved susceptible in the field to malathion, demeton and EPN, but that of LIENK *et al.* (20), while remaining susceptible to demeton and EPN, appeared slightly resistant to malathion. CUTRIGHT (5) states that the strain originally showing parathion resistance was susceptible to demeton, but that in 1957 a further strain was found in Wooster, Ohio, that was resistant to demeton and trithion in addition to parathion.

Parathion resistance in two further mite species, *Tetranychus pacificus* and *T. mcdanieli*, is reported from the Yakima Valley, Washington, by NEWCOMER and DEAN (24). These mites proved susceptible to malathion, EPN and demeton. *T. pacificus* has been reported as resistant also by ANDRES and REYNOLDS (1). In 1956, demeton failed to control *T. pacificus* in the San Joaquin Valley, California, and *T. atlanticus* in the Palo-Verde Valley, California, and in 1957 failed also against *T. cinnabarinus* in the Coachilla Valley, California. Though demeton was the insecticide that failed in the field, and to which these strains must be presumed to be resistant, laboratory tests were run on all three species using parathion and trithion. To these two, *T. pacificus* was found to be X200 and X35 times resistant respectively, and *T. atlanticus* X90 and X33 times respectively. The resistance of *T. cinnabarinus* to parathion was found to be similar to the other two species.

JEPPSON *et al.* (14) have reported on a demeton resistant strain of *Paratetranychus citri* from California in 1957. Laboratory tests revealed that this strain was resistant to 14 other OPs in addition to demeton. The resistance factors obtained for this strain for certain OPs are extremely high, for example X15,000 for trithion, X883 for parathion and X350 for Phosdrin*, when compared at the LD50 level, values twice as high being obtained when comparison is made at the LD95 level.

Aphids

Resistance of an aphid to an OP was first reported by MICHELBACHER *et al.* (22). In 1952 parathion failed to control a population of *Chromaphis juglandicola* at San José, California. Laboratory tests revealed a resistance factor of X7 compared on LD50 values. ANTHON (2) has reported failure of parathion and malathion against *Myzus persicae* on potatoes in 1952 in the Yakima Valley, Washington, and against the same species on peaches in north central Washington in 1953. In both cases, laboratory reared colonies proved not to be resistant to parathion, malathion or demeton. On potatoes TEPP also failed in the field, while on peaches both TEPP and demeton proved effective.

KNIPLING (17) has reported parathion resistant strains of *Myzus persicae* and *Macrosiphum solanifolii*, both from the USA, while parathion resistance in three aphids, *Myzus cerasi*, *Sappaphis piri* and *S. plantaginea*, is reported from Europe (31). Better authenticated is the resistance developed by *Therioaphis maculata* in S. California reported by STERN and REYNOLDS (29). Parathion and malathion first failed to give control in 1956. Phosdrin and demeton also failed in the field. A low degree of resistance to parathion and trithion was found in the laboratory, a factor of X4 to parathion for instance.

Disease Vectors

Three insects of public health importance, the house fly, one mosquito species and a latrine fly, have shown resistance to OPs. The mosquito, *Culex tarsalis*, developed resistance to malathion in the San Joaquin Valley, California, in 1956 (11). Five field collections showed malathion resistance, and no cross resistance to parathion was detected. The resistance factors to malathion determined in the laboratory were high, X94 and X21 for adults and larvae respectively, compared at the LD50 level.

The first indication of resistance to OPs being developed by the house fly, *Musca domestica*, was given by KEIDING (15). In Denmark in 1954, control programmes with parathion and diazinon were introduced, and in 1955 Resitox was included. By July, 1955, failures with Resitox were being widely reported, notably in the South Zeeland area. A strain from Skelskor was found by a topical application technique to have a resistance of from X8 to X45 to Resitox compared with laboratory strains at the LD50 level. Even higher resistance factors to Resitox are claimed for strains from areas where only parathion and diazinon had been used. For example, a strain from a farm in North Jutland sprayed only a fortnight before with parathion showed a X500 resistance to Resitox. These strains showed less resistance to diazinon (X3 to X15) and parathion (X2 to X3). The presence of strains similarly resistant to parathion and diazinon in Sweden is also reported (6). A strain from Nasa, Sweden, which had developed a ten-fold resistance to synergised pyrethrins, also showed a resistance to parathion (X6) and diazinon (X30) equal to the highest measured in any Danish field population. Diazinon resistance has also been reported from Wallis, Switzerland, and Latina, Italy, in 1957 (3).

The first reports of house flies resistant to OPs in the USA are those of LINDQUIST (21), and LABREQUE and WILSON (18) from Florida. In late 1956 and early 1957, failures of malathion baits were reported, and resistance was widespread by April, 1957. Laboratory tests on four wild caught strains in 1957 revealed resistance factors of from X4 to X6 for malathion, and X3 to X6 for dipterex, compared on LD 50 values, and factors as high as X20 compared at the LD95 level. Further tests (19) on 14 wild caught strains from central and southern Florida revealed that all 14 strains showed malathion resistance (X3 to X133), the 11 strains tested were resistant to dipterex (X1.3 to X72), the five strains tested were resistant to diazinon (X5 to X38), and the seven strains tested were resistant to parathion (X3 to X18), all comparisons at the LD50 level.

Further resistant strains have been reported from the USA during 1958. A malathion resistant strain developed

*Phosdrin is a Shell trade mark.

Table I

Table connecting resistant species with compounds to which resistance has been developed.

	Amiton	Chlorthion	Delnav	Demeton	Demeton, Methyl	Diazinon	Dicapthon	Dipterex	Disyston	Dithion	Ethion	EPN	Iso-systox	Malathion	Paraoxon	Parathion	Parathion, Methyl	Phosdrin	Pyrazoxon	Resitox	Ronnel	Schradan	TEPP	T isopropyl PP	Trithion	O-ethyl O,O-bis-(p-nitrophenyl) phosphorothionate
ACARINA																										
Metatetranychus ulmi Koch																										
Paratetranychus citri McG.																										
Tetranychus atlanticus McG.				×?																						
T. cinnabarinus (Bois.)				×?																						
T. mcdanieli McG.																										
T. pacificus McG.				×?																						
T. telarius L.																										
Vasates schlechtendali (Nal.)																										
HOMOPTERA																										
Chromaphis juglandicola (Kltb.)																										
Macrosiphum solanifolii Ash.																										
Myzus cerasi (F.)																										
M. persicae (Sulz.)														?		?										
Sappaphis piri (Fonsc.)																										
S. plantaginea (Pass.)																										
Therioaphis maculata (Buckt.)																										
DIPTERA																										
Culex tarsalis Coqu.																										
Musca domestica L.																										
Chrysomyia putoria (Wied.)																										

during 1957 in a dairy barn near Savannah, Georgia (8,16). This strain, colonised in the laboratory, showed a X2.4 resistance at the LD50 level and a X7 resistance at the LD90 level to malathion. A strain derived from it by exposure to malathion showed X14 and X42 resistance factors respectively. Three strains all resistant to malathion, diazinon and parathion from Arizona and Georgia (including the above strain from Savannah) are mentioned by SCHOOF and KILPATRICK (27). HANSENS (12) reports on five wild caught strains from New Jersey which all showed some resistance. Diazinon, parathion, malathion, dicapthon, ronnel, dipterex and Resitox were the insecticides involved. An interesting laboratory study on three field caught strains, from Denmark, Italy and Savannah, is that by BUSVINE (4).

The latrine fly, *Chrysomyia putoria*, has developed resistance to diazinon in Leopoldville, Belgian Congo (3). A resistance factor of X6 to diazinon in 1954, increased to

X300 in 1955, with cross resistance extending to malathion, chlorthion and EPN. However, malathion remained effective enough to be substituted for diazinon to control the fly, but this led to increased resistance developing to malathion.

General Inferences

From the foregoing, it does not appear that the emergence and spread of strains resistant to OPs in the field has progressed in a significantly different manner from that of strains resistant to chlorinated hydrocarbon insecticides, bearing in mind that OPs have had relatively a much wider application against agricultural pests, and until recently very little application in public health.

It seems that wherever OPs have been widely and frequently applied so that they affect a high percentage of the population of a species, a resistant strain of that species has tended to emerge. In certain cases, notably amongst the mites, several years have elapsed between the first use of a chemical and the development of resistance. In at least one instance such resistance has been shown to be due to a monofactorial dominant gene (30), so the gene must have been present in the original population at very low frequency. This has usually been the case with the development of resistance to chlorinated hydrocarbons and other compounds. The monofactorial dominant gene conferring parathion resistance in a mite (30) would parallel the case of the semi-dominant gene conferring dieldrin resistance in *Anopheles gambiae*. Another characteristic of *A. gambiae* resistance to dieldrin, the fact that the gene for resistance was frequent in the original wild population, thus leading to a rapid development of a resistant population on spraying, would appear to be paralleled by the case of Resitox resistance in the house fly in Denmark (15). Here a population resistant to Resitox was collected only a fortnight (one generation?) after a parathion spray. It is also interesting to note that in areas where OPs have been extensively used, several pest species have often developed resistant strains. For instance, resistance is reported in eight species from California, in four species from the Yakima Valley, Washington, and in two (perhaps three) species from the Okanagon Valley, British Columbia.

It would seem that resistance to any insecticide is less liable to arise in an agricultural pest than in a public health one. When dealing with vector species of public health importance, a virtually complete control (eradication) over a wide area is necessary before the full beneficial effect will be felt. Thus any control measure must be directed at a very high percentage of the total population of a species, and it is under these conditions that resistance is most likely to develop. Such co-ordinated eradication programmes over wide areas are much less frequent in the case of agricultural pests. For though vast campaigns are undertaken against such pests as locusts, the great mobility of the pest and its wide distribution mean that at any one time only a tiny percentage of the total population is receiving treatment, and the selection pressure is therefore very low. In the agricultural field, it is among the mites that OP resistance has most often and most widely occurred, and it is precisely here, with a fast breeding pest, where frequent applications have to be made to effect any commercially acceptable control at all, that selection pressure will be greatest.

Most reported cases of OP resistance in the field have necessitated the dropping of at least some OPs as standard control chemicals in the area concerned, though, in some instances, certain OPs do remain effective while resistance to others precludes their use. However, the case of *Metatetranychus ulmi* reported by CUTRIGHT (5) should serve as an indication that, just because resistance did not develop to a second (replacement) OP at the same time as it did to the initial one, it will not do so at a later date. Present indications are that resistance to OPs is most acute as a practical problem among the mites. However, it would appear that once again the house fly is proving a resilient and adaptable pest, and that the recently adopted control measures involving organo-phosphorus insecticides are already in jeopardy, at least in certain areas.

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Aldrin, Dieldrin and Endrin: Effects on Soil Micro-Organisms

The Literature Surveyed

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Micro-organisms are responsible for many important organic and mineral transformations in the soil: nitrogen of plant or animal origin, or from the air, is converted into ammonia and nitrate; the carbon of organic material is oxidised into carbon dioxide or carbonates; organic compound minerals as well as minerals from inorganic soil constituents are made available to the plant, and other transformations take place. It is therefore important that the use of agricultural chemicals should not eradicate these favourable forms of life nor disrupt their activities for prolonged periods.

Of the many pesticides used in agriculture, soil insecticides are the most potentially dangerous to soil micro-organisms, since they are usually intimately mixed with the soil at fairly high dosage rates. As early as 1946 WILSON and CHOUDHRI (33) published a paper on the effect of DDT on soil micro-organisms. Since then other workers have included in their research newer insecticides which are now more widely used than DDT for soil application. The present review of the literature is particularly concerned with the effect of aldrin, dieldrin and endrin on soil micro-organisms, although other chlorinated hydrocarbon insecticides used in soil application are also taken into consideration.

Effect on Biochemical Processes

The study of biochemical soil processes such as nitrification and ammonification forms a means of assessing the activity of certain bacteria involved in these processes. Since soils vary in chemical and physical characteristics, in organic matter content and microbial population, the results obtained on the effect of insecticides on the biochemical processes are necessarily valid for one soil type only and are not directly applicable to other soil types. JONES (18), for instance, indicates that the effect of insecticides on soil micro-organisms is less in soils with a high organic matter content than in those with a low organic matter content. This being the case, it is not surprising that authors differ in opinion as to the maximum safe dosage rate levels. Fortunately, as will be seen, the safe dosage levels are so high that they are of theoretical value only.

Nitrification (references 2, 4, 7, 8, 9, 10, 11, 12, 17, 18, 24, 25, 33, 34)

In general, it has been found that most chlorinated hydrocarbon insecticides when applied at dosage rates of 200lb. per acre or more reduce nitrate production. DDT, TDE, methoxychlor and toxaphene seem to be least toxic; and BHC (in particular the *gamma* isomer) and, to a lesser extent, chlordane and heptachlor, seem to be most toxic. Aldrin, dieldrin and endrin hold an intermediate position.

Ammonification (references 2, 4, 7, 10, 18, 24, 25, 33)

The effect of chlorinated hydrocarbon insecticides on ammonification is even less than that on nitrification. At extremely high rates, e.g. 1,000lb. per acre, many insecticides seem to stimulate ammonia production; at still higher rates some insecticides such as DDT, chlordane and BHC, may in some instances become inhibitory.

Carbon Dioxide Evolution (references 2, 9, 10)

Carbon dioxide evolution seems to be increased by some insecticides, notably toxaphene, TDE, DDT and dieldrin applied at rates of 25-200lb. per acre; aldrin increases carbon dioxide production when applied at still higher rates.

Sulphur Oxidation (reference 18)

As far as can be ascertained, only one worker has studied the effect of chlorinated hydrocarbon insecticides on the oxidation of sulphur to sulphates. JONES found that chlordane, and to a lesser extent BHC, were more detrimental than DDT to sulphur oxidising organisms; DDT became toxic at a rate of 200lb. per acre. Aldrin, dieldrin, endrin and methoxychlor did not have any immediate effect when used at concentrations 10 times those recommended for general usage.

Effect on Nodulation (references 1, 2, 6, 8, 9, 11, 22, 25, 31, 32, 33)

The effect of insecticides on symbiotic nitrogen-fixing bacteria such as *Rhizobium radicicola* and *Rhizobium leguminosarum* can be indirectly measured by a count of the nodules on random samples of legume roots. From the published literature (6, 9, 22, 25) it is apparent that BHC and in some instances DDT may seriously affect the nodulation of legumes (whether inoculated or not). Aldrin seems to be detrimental if used at such excessive rates as 100lb. or more per acre.

Working with seed dressings, STARKS and LILLY (31) found that dieldrin, heptachlor, lindane and toxaphene

applied at 2oz. per bushel did not affect the yield of inoculated or uninoculated soybeans.

Effect on Total Numbers of Soil Micro-organisms (references 3, 4, 8, 9, 10, 11, 16, 17, 18, 20, 21, 30, 33, 34)

Most authors agree that chlorinated hydrocarbon insecticides applied at normal rates do not significantly influence the total number of soil micro-organisms or the total number of bacteria and fungi. At higher rates aldrin, BHC and DDT may increase the number of bacteria, and dieldrin, DDT and toxaphene the number of fungi. Aldrin and BHC seem to reduce populations of fungi. Differential counts of the organisms concerned have seldom given conclusive results. FLETCHER and BOLLEN (10) mention that aldrin does not affect the development of *Azotobacter* on soil plaques. Owing to the fact that different soils were used, the data differ from author to author.

Effect on Specific Micro-organisms (references 2, 12, 13, 14)

AYERS and ALLEN (2) studied the effect of aldrin on specific micro-organisms by adding aldrin to culture media and found that aldrin may inhibit certain bacteria, i.e., *Bacillus subtilis*, *Corynebacterium tumescens*, *Micrococcus pyogenes var. aureus*, *Sarcina lutea* and two *Streptomyces sp.*, and two fungus species, *Hormodendrum sp.* and *Monilia sp.* This inhibitory effect seemed, however, to be transitory, and most of the micro-organisms occurring in the plating of soils appear not to be influenced by aldrin applied at normal dosage rates.

GRAY (12, 13, 14) studied BHC in a similar way and found that it was toxic to nitrifiers in solution cultures, but not in soils; lower concentrations of the commercial insecticide depressed urea-hydrolysing bacteria, although the *gamma* isomer had no effect. BHC also inhibited the growth of many strains of heterotrophic bacteria but most of these were again not affected by the *gamma* isomer.

Effect on Pathogenic Fungi (references 23, 29, 34)

Some research workers have tested the effect of insecticides on fungus diseases. BHC, in particular the *delta* isomer, seems to be toxic to *Rhizoctonia* (it is also toxic to mycorrhizae) and aldrin, but not lindane, seems to give control of *Helminthosporium sativum* on barley; heptachlor increases the incidence of the latter disease. It should be noted that it is extremely difficult to attribute disease control to insecticides as such: commercial aldrin, for instance, contains impurities which have strong fungicidal properties; furthermore, soil insect control often reduces the attack of secondary fungi and bacteria. These factors combined are probably responsible for the control of potato scab when aldrin is used for wire-worm control (unpublished trials in the UK.)

Utilisation by Soil Micro-organisms (references 2, 5, 10, 19)

AYERS and ALLEN (2) and FLETCHER and BOLLEN (10) have noted that colonies of certain soil micro-organisms may develop in contact with aldrin crystals. Ayers and Allen observe that 'typical bacterial colonies were produced on silica-gel plates containing aldrin as the sole source of energy. These colonies developed initially around one or more surface aldrin crystals which disappeared under the action of these organisms. Microscopic examinations of bacterially surrounded crystals showed increases in bacterial numbers during the course of diminution and eventual disappearance of the aldrin crystals.' Although it is therefore certain that microbial utilisation of aldrin can occur it has not been possible to measure these changes quantitatively and they are probably insignificant on a short-term basis (5, 19).

Effect on Soil Fauna

SATCHELL (26) has prepared an excellent review of the effects of BHC, DDT and parathion on soil fauna, excluding insect pests, which could be extended to include newer insecticides (27, 28). The information available on aldrin, dieldrin and endrin is very scarce and fragmentary, but it may be mentioned that there is evidence to show that aldrin, dieldrin and endrin applied at normal dosage rates do not affect earthworm populations (15, 20, 32).

Conclusions

It is evident from the available literature that chlorinated hydrocarbon insecticides applied to the soil at normal dosage rates do not have a detrimental effect on soil micro-organisms or soil biochemical processes. So far as aldrin and dieldrin are concerned, normal dosage rates are of the order of 2-6lb. per acre and 1-3lb. per acre respectively; assuming that danger exists when these insecticides are applied at 100-200lb. per acre it seems improbable that residues will build up to a dangerous level.

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ANIMAL PARASITES CONTROLLED WITH TEEPOL[1]

Recent work on one species of rumen fluke, *Carmyerius dollfusi*, a trematode parasite of frequent occurrence in sheep and cattle in Madagascar, has led to the recommendation of Teepol 410 (a mixture of sodium alkylsulphates) for its control. This treatment has the advantage of being cheap, easily administered and highly effective.

The story of how Teepol was discovered to be an effective anthelminthic for *C. dollfusi* control is an interesting one. This parasite, which is a pear-shaped trematode infesting the rumen, is extremely difficult to control with the orthodox anthelminthics since the food mass normally found in the rumen prevents effective contact between anthelminthic and parasite.

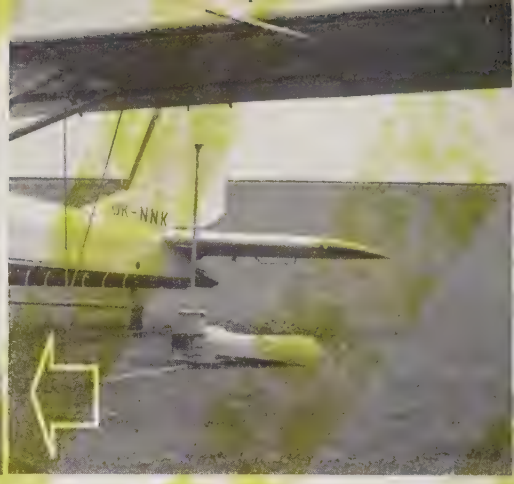
Early work carried out at the Department of Parasitology of the Central Stock Breeding Laboratory, Tananarive, had shown a mixture of dichlorobutane-chlorobutene to be effective against *C. dollfusi* but the treatment was too expensive for local use. In 1958, at the same station, Dr. S. G. Gretillat and Monsieur R. Daumas started a series of *in vitro* tests for the control of the trematodes in the rumen with oil of turpentine, petroleum ether and butyl alcohol; none of these materials was effective, and DDT and BHC, which were then tried, also failed to give control. However, it was thought that the addition of a wetting agent might enable the insecticide to reach the parasites more easily. Teepol was tried as the wetting agent and the results were outstandingly good, all the trematodes being killed within 10 minutes.

Further experiments were carried out using another chlorinated hydrocarbon insecticide, lindane, but this material could not be formulated with Teepol and results were mediocre. This led the workers to suggest that the Teepol itself might have been the active constituent of the successful formulation, and they accordingly carried out further *in vitro* tests using solutions of Teepol in water at strengths of one part in a thousand, one in two thousand and one in five thousand. The parasites were effectively controlled in each case, the strongest solution killing them in two hours.

The next step was to carry out tests on live animals; for this purpose a silicone-based anti-foaming agent was added at the rate of 5 cc. per litre of Teepol. Again, results were good, the effective dose being 0.06 gm of Teepol per kg. body weight of the animal.

One practical recommendation is that Teepol should be administered as an anthelminthic on a full stomach. For a calf of 80 kg. the dose is 25 cc. of Teepol 410 diluted with an equal volume of water, with 5 cc. of silicone-based anti-foam agent added per litre of solution.

[1]Teepol is a Shell trademark.



The Omnipol Czech L 60 Brigadyr made its first appearance in Europe at the demonstration. Right: *the backward-curving horn-shaped nozzles may be replaced by the fertiliser distributor shown here on the ground; it is attached behind and below the cockpit.*

Farm Flying Looks Ahead

Europe's first international agricultural aviation conference, which took place in Britain last autumn, attracted some 250 delegates from 23 countries; they represented farming, aircraft operating, research, and both aircraft and chemical manufacturing interests.

Held at the College of Aeronautics, Cranfield, Bedfordshire, the conference was sponsored by the Ministry of Agriculture in conjunction with other Government departments and various scientific and trade associations; a prominent part was taken in its organisation by the European Agricultural Aviation Centre (established in Holland in 1957 by the Organisation for European Economic Co-operation).

Progress in agricultural aviation throughout the world has been very varied, since some countries have been much readier than others to take advantage of new developments in agricultural aircraft, application techniques and chemicals in an attempt to reduce pest and disease epidemics and outbreaks, and raise crop productivity.

By the end of the conference one was left with the clear impression that it is in the USA and New Zealand that aerial spraying has chiefly made its mark so far. In these countries the wide range of agricultural aviation operations now practised includes the application of insecticides, fungicides, weedkillers, fertilisers and trace elements, rodenticides, rabbit and deer poisons, and the dropping of fencing material. Some idea of the rapid development of agricultural aviation in these two countries can be gained from the following figures. In the USA in 1926, 5,000 acres —entirely cotton—were aerially sprayed; by 1957, the area treated was 39 million acres; by 1958, 4,000 pilots were treating 60 million acres, 80 per cent of the work being dusting and spraying.

In New Zealand, the development of agricultural

The Djinn helicopter (Helicop-Air, France). The rapid manoeuvrability and ease of control of this machine were evident at the demonstration.

Fertiliser being loaded into the hopper of a Tiger Moth, using a specially designed loader made by Crop Culture (Aerial) Ltd.

Low level flying by the Jackeroo (Jackeroo Aircraft Company, UK). This aircraft was fitted with Allman nozzles for low volume spraying.

An Auster Agricola (Auster Aircraft Company, UK) spreading fertiliser at the demonstration.

Miss Kerssen, Netherlands Plant Pathological Service, the only woman delegate at the conference, and Mr. W. R. Caseby, Shell Chemical Company, examine one of the Micronair rotary atomisers (Britten Norman Ltd., UK) fitted to a Tiger Moth.

Mr. N. D. Norman, Crop Culture (Aerial) Ltd., discusses his company's new Spraypack, designed for the De Havilland Beaver, with Dr. W. J. Maan, Director of the European Agricultural Aviation Centre. It incorporates a 75gal. tank with pump and atomisers.

aviation has also been very rapid. Until 1945 the steep and hilly nature of much of the land in New Zealand, combined with a shortage of labour, restricted the extensive exploitation of marginal land and made the fullest development of much productive land uneconomical. By aerial application a new way was found round the difficulties, and in 1958, out of 890,000 tons of phosphatic fertilisers manufactured in New Zealand, 48 per cent was spread from the air—of every 10 acres top dressed, the aeroplane did four and a half. In addition, aircraft spread 8,000 tons of pasture seed over 163,000 acres, dropped 4,300 tons of rabbit poison and sprayed nearly 800,000 gallons of insecticides, fungicides and weedkillers.

Elsewhere, within the last few years, aircraft have played an increasingly important part in the control of banana leaf spot, in Central and South America and the Cameroons, locusts in the Middle East and North Africa, and forest insects in Canada. These operations are carried out by contracting companies using either war surplus aircraft or machines specifically designed for agricultural aviation.

In the United Kingdom, agricultural aviation is less extensively developed, operations being chiefly restricted to the application of fungicides (mainly against potato blight) and fertilisers (largely nitrogenous top dressings). Aerial application of weedkillers is not employed, because of the dangers of drift hazard, and this practice is unlikely to become established in Britain until successful means of preventing drift have been developed. Drift may be reduced by the use of specialised herbicide formulations—particularly invert emulsions—low-level flying and the passing of restrictive legislation. For this work there is a limited season, from February to the end of August, which limits the amount of business which British contractors can obtain at home. British operators therefore find it necessary to seek contracts in such countries as the Sudan, West Africa, Latin America and the West Indies.

The economics of aerial spraying in Britain were reviewed by Mr. N. D. Norman of Crop Culture (Aerial) Limited. He pointed out that although pilots in Britain are legally allowed to do 120 hours of commercial flying every 30 days, the maximum number of productive flying hours per season is only 400. Although many agricultural aviation operations such as top dressing and the application of trace elements may be carried out throughout the year, this annual potential is seldom achieved because of unfavourable weather and time wasted on unproductive work.

Mr. Norman suggested that a fixed-wing operator, working for 400 productive flying hours per season with a 500lb. pay load agricultural aeroplane valued at £3,200, would be able to operate at a cost of about £13 per hour, if he was an owner-pilot. Such an operator would work direct with farmers and would not provide loading personnel or equipment and markers. Larger operators who provided ground support and markers incurred heavier overheads, which might bring the total cost per productive hour up to £22. A comparable charge for helicopters would be about £36 10s. per hour. Aerial spraying operators had to provide an economic and efficient service, and returns needed not only to cover these costs but also to make allowance for marketing costs, the reserve of operational capacity and a profit margin. Aerial spraying charges per acre must inevitably be considerably higher than those for ground spraying, Mr. Norman implied.

The enormous potential market for agricultural aviation operations throughout the world has barely been touched, and experimental work has only recently been started with fertilisers on forests and insecticides and fungicides on fruit and forest trees.

A wide difference of opinion exists between agricultural aviation operators, pilots and aircraft designers about the necessity or desirability of having aircraft specifically designed for agricultural use. As war surplus aircraft are scrapped, so this problem becomes more important. No single aircraft is capable of performing all the operations required in agriculture, and since many companies engaged in crop spraying also practise aerial photography or surveying, specialised aircraft may be unsatisfactory. Nevertheless, in spite of the wide use to which aircraft are put in agriculture, specialised agricultural aircraft have been designed following a careful consideration of, for example, resistance to corrosion, comfort of the pilot, and ease of attachment of spray tank or fertiliser hopper. Such aircraft include the Auster Agricola and Auster Workmaster (Auster Aircraft Limited, UK), the Ceres (The Commonwealth Aircraft Corporation, Australia), the Jackeroo (Jackeroo Aircraft Company, UK), and the Edgar Percival EP 9 (Edgar Percival Company, UK). Distribution equipment such as the Micronair (Britten-Norman, UK) rotary atomiser, and the Swathmaster (Transland Aircraft, USA) has been designed specifically to apply chemicals from many types of aircraft accurately and evenly.

Amongst the many aircraft which appeared at the flying demonstration on the final day of the conference, the Czech L.60 Brigadyr (Omnipol, Czechoslovakia) monoplane attracted much attention, as it had not been seen in Britain before. Its short take-off and backward curving 'horn' nozzles were particular points of interest. A new piece of equipment to attract notice was the Britten-Norman Spraypack, designed specifically for the De Havilland Beaver. This self-contained unit contains a 75gal. spray tank with pump and atomisers. Although the original units were designed primarily to enable the Beaver to be used effectively for locust control, they can be fitted to many other makes of aircraft for agricultural spraying.

Experience so far gained in the use of aircraft for agricultural purposes throughout the world suggests that aviation can play an important part in raising crop productivity. As new chemical formulations are developed and new aircraft and distribution equipment are designed, so aviation will become established for agricultural operations. The conference at Cranfield struck a note of cautious optimism; what developments, one is left wondering, will the next decade see?

J. R. Johnston
G. R. Tickler

Books

The World of Insects. PAUL PESSON (translated by R. B. Freeman). Harrap, London. 63s.

The World of Insects has been written for the enquiring layman by Professor Paul Pesson, one of the leading insect physiologists of France. After the origin, fossil history and relationships of the insects have been briefly discussed, and the reader has been shown photographs or line illustrations of some of the major groups, the writer uses the remainder of the 80 pages of text to consider the basic problems associated with the way insects live.

In so many ways insects contrast with the more familiar vertebrate animals that many will be fascinated to learn how insects breathe in water, and how the aerial kinds manage to breathe without also drying up. The author goes on to describe the reactions of insects to heat and cold, and how they react to climatic changes. Sexual behaviour and the methods of laying eggs form the subjects of another fascinating chapter, which is followed by one on insect development, growth, moulting and on parental care, which is so strikingly shown in insects like wasps, ants, bees and termites. Insect senses of sight, hearing and smell, and their behaviour are dealt with in some 10 pages of text. The importance of insects to man as carriers of disease or as destroyers of crops and the methods of controlling pests are summarised in three pages.

The translator has done his work well, but at least one French word intrudes. Occasionally the scientific jargon becomes a bit oppressive, and those who have not done any biology at school may feel that the translator could have used more homely English without loss of clarity. One or two errors have crept in at some stages. For instance, the force exerted by a muscle is said to be related to its surface area, instead of to its cross-section area; the geometry of the dance of the honey-bee is wrongly described; and crane flies are incorrectly said to be predaceous. These are minor blemishes in a book which is readable, authoritative and up to date.

The most attractive feature of the book is the 16 pages of beautiful colour photographs and 80 pages of photogravures. With few exceptions these are of very high quality and portray insects with striking realism. Nervous readers would have been reassured if the magnification had more frequently been given, and the full legends of the coloured plates could easily have been put facing them instead of being hidden in an appendix.

Books of this type tend to show evidence of their composite origin, and the plates and the text are not as closely correlated as they might be. For instance, the details of binocular vision in the water boatman are given without reference to the excellent pictures of the insect, from which their visual field can be inferred. Perhaps also because another book of the series is devoted to butterflies and moths, this volume illustrates other kinds of insect. Those who have experimented with insect photography will not be surprised that most of the subjects of the coloured illustrations are insects of an inch or more in length, but there are also some technically difficult

shots of smaller forms, of which the beautiful picture of a ladybird and a crab spider which has captured a hover fly on a purple thistle is quite outstanding.

It used to be said that the camera never lied, but in colour photography and reproduction it is still impossible to ensure perfect colour balance. Two of the plates purport to demonstrate the adaptation of the colour of grasshoppers and stick insects to their background. Convincing evidence can be provided only if the photograph includes a small colour chart in the field of view; without this it must be very tempting to over-emphasise the differences in the processing.

Many will find delight and instruction in this handsome book, and its possessors will be rightly proud. G. C. VARLEY.

Plant Nematodes, their Bionomics and Control. J. R. CHRISTIE. University of Florida, Gainesville, Florida, USA. $3.75 domestic; $4 foreign.

It is almost nine years since a major book on plant parasitic nematodes was published (the last was the late Dr. Thomas Goodey's *Soil and Fresh Water Nematodes* [1951]), so that the appearance of a new book on the subject is an event in itself. When that book turns out to be one of such usefulness as Dr. Christie's *Plant Nematodes, their Bionomics and Control*, the event is one of special interest.

A recognised authority on plant nematodes in the USA, where he is nematologist at the Agricultural Experiment Station, University of Florida, Dr. Christie has summarised in his new book, in something under 250 pages, what is at present known about the life cycles, ecology, injuries to host plants and control of nematodes. He does not include taxonomy and morphology. While it is difficult to single out one section of this book as being of greater interest than any other it may well prove to be the chapter on control that will attract most attention; for this chapter summarises all the available information on plant nematode control and, in the case of chemical control, provides a particularly useful guide to choosing between the various nematicides now on the market.

Plant Nematodes may be considered as consisting of four parts—although they are not described as such. First, there is a good introductory chapter which describes plant nematodes, their biology, their natural enemies, and the symptoms of damage which they cause to plants. There follows a very complete account of control methods, after which come a series of chapters dealing with practical aspects of specific groups of nematodes. Finally, there is an appendix containing a number of exceedingly useful tables.

In the introductory chapter, discussing symptoms of plant injury by nematodes, the author points out that, contrary to popular belief, most nematode species do not cause galling in plant roots; root galls are usually a symptom of injury by root-knot nematodes, *Meloidogyne* spp., although nematodes of *Nacobbus* spp. also cause galling on some plant species, and some cereals and grasses attacked by *Ditylenchus radicicola* develop small root galls. Many other nematode species, including such external feeders as the dagger nematodes, *Xiphinema* spp., may cause moderate swelling of the roots which, if localised, results in small enlargements similar to galls. Dr. Christie also points out that often the symptoms of nematode attack seen on a plant are in fact the result of attack by several different nematode species, and also that the same nematode may produce different types of symptoms in the same plant; then he reminds us that nematodes may increase the susceptibility of crops to attack by other organisms. Cotton, as is well known, may suffer from a combined attack by nematodes and Fusarium wilt, and cauliflower disease of strawberries is caused by a bud and leaf nematode (*Aphelenchoides* sp.) in combination with the bacterium, *Corynebacterium fascians* (Tilford) Dowson.

Dealing with plant nematode control, the author lists and describes seven methods: heat (heat treatment of the soil and hot water treatment of the plants); fallowing; crop rotation; biological control; the use of organic matter and mulches; root diffusates; and chemical control.

More space is devoted to the chemical control of nematodes than to all the other control methods together, and the author provides an admirable review of the subject. He sets out by explaining that two main difficulties are involved in controlling nematodes by chemicals: first, there is the problem of finding an effective material, because nematodes are resistant to most chemicals; secondly, there is the difficulty of applying these chemicals.

It was at one time fashionable to postulate the properties required in a chemical to make it an ideal soil fumigant; now, as Dr. Christie observes, 'it is becoming increasingly obvious . . . that there is no such thing as an ideal nematicide or even an ideal soil fumigant. A chemical with properties that would make it ideal for one purpose or use under one set of conditions might make it quite unsuitable for another purpose or use under another set of conditions'. There follows a useful account of the principal soil fumigants now in use, and the applications for which, in the author's opinion, they are best suited.

One of the biggest problems in the application of chemicals for the control of root-infesting nematodes is that of bringing the chemical in contact with the nematode, and in this book the author gives the 'pros and cons' of the three methods used: gaseous diffusion through the soil of volatile liquids; dispersion in water; and mechanical mixing. He then gives practical advice on soil fumigation.

The major part of *Plant Nematodes* is devoted to twelve comprehensive chapters on the various groups of nematodes encountered as plant pests. Each group is dealt with in broadly the same way, under such headings as Introduction, Life History, Feeding Habits, Injury to Plants, Hosts, Nature of Resistance in Plants, Distribution and Spread, and Control. These chapters, like the others in the book, all end with a complete list of references.

Finally, there is the appendix, which for rapid reference may prove to be the most useful part of this useful book. It consists of five tables. In the first, a number of crops is listed, with the nematodes associated with each and the regions (chiefly in the USA) where damage is known to occur. Table 2 sets out control methods for different nematodes infesting various crops. Table 3 gives details of hot water treatments for killing nematodes on planting stock; and the last two tables list, respectively, the common and scientific names of nematodes.

Dr. Christie's book deserves to become a *vade mecum* for all field nematologists; one hopes that it will receive the widest possible attention. J. G. R. STEVENS.

The Scientific Principles of Crop Protection. (4th edition, 1959) HUBERT MARTIN. Arnold, London. 65s.

This book is concerned with the principles underlying the control of the insects, nematodes, weeds and fungi causing injury and disease to crop plants. The author states in his preface that its primary purpose is to assist the co-operation between the entomologist, mycologist, physicist, chemist and plant physiologist concerned with plant protection. Such

co-operation would appear essential if mistakes are to be avoided and orderly and rapid progress made and the author can feel satisfied that he has achieved his objective.

The first three chapters deal with more general subjects—plant resistance to insects and pathogens, the effect of nutritional, climatic and other external factors on the susceptibility and liability of the plant to attack, and biological control. The following six chapters deal with fungicides and insecticides and include a discussion of the principles underlying the formulation of the chemical for application, the measurement of toxicity and hypotheses on the mechanics of toxic action. In addition, the action on the pest organism and the plant of the different groups of fungicides and insecticides are discussed, and some consideration is given to the relation between chemical structure and toxicity. The remaining six chapters deal with weedkillers, fumigants, seed treatment, soil treatment, traps and chemotropism and the treatment of centres and vectors of infection.

A book of this size covering so many aspects of a rapidly developing subject cannot hope to do much more than outline the important fields of work within the subject—their stage of development and what general principles, if any, have been derived in the course of the work. Any specialist reading the chapter dealing with his own particular subject may feel that too much has been left out, but there is now a considerable number of reviews and text books dealing fully with specialist subjects and the book would fail in its objective to present a broad picture if too much detail were included. Each chapter is documented and anyone wishing to follow up any particular aspect should, in most instances, have no difficulty in doing so.

It seems that the outlook of any specialist reading this book cannot fail to be broadened and that he will be made more aware of the complexity of any problem of plant protection and of the numerous ways in which it may be approached.

The demonstration of scientific principles on which crop protection is based is not easy. A great deal of the work on which the science of crop protection, particularly the use of chemicals for crop protection, has been built up, has been largely empirical. Any generalisations that can be made are not sufficiently wide to prevent the whole subject from appearing to be a somewhat heterogeneous collection of data amassed during a series of unco-ordinated efforts to prevent crops from being destroyed by diseases and fungi. In this book the author has considered these data, selected those that allow some general inference to be drawn and placed them under an appropriate subject heading. Where consideration of the data in the subject heading leads to generalisations these are stated. This is probably the best that can be done at present and the book serves a most useful purpose is enabling the various aspects of the subject to be considered together rather than separately which is more usual. C. Potter.

Maladies of Hevea in Malaya. Roger N. Hilton (with water-colours by Hoh Choo Chuan). The Rubber Research Institute of Malaya, Kuala Lumpur. M$30.

The features that distinguish this book from the general run of text books on crop diseases are the clarity and conciseness of the descriptions, the convenience of its arrangement (whereby the description of each disease or disorder faces the plate depicting it), and the superb quality of its coloured illustrations, which have been so faithfully reproduced by the printers—the Kynoch Press.

According to the author's Foreword the book has been prepared primarily as a recognition manual for the planter in Malaya. However, it seems destined to have more than a purely Malayan appeal. Many of the diseases and disorders described have a world-wide distribution, so it should prove an invaluable aid to all concerned with rubber cultivation irrespective of where they may be situated.

Forty-one 'maladies' are described. About half of these are diseases caused by parasitic fungi. The remainder (with a few exceptions) are injuries induced by a variety of agents, such as waterlogging, drought, lightning and fire. The exceptions include abnormalities, some attributed to physiological disturbances and others whose cause is not yet known. The symptoms exhibited by two of these abnormalities (oil-spot and genetic yellows) are very suggestive of virus infections, but neither has been found to be transmissible by grafting.

Disorders resulting from mineral deficiencies receive only a brief mention, for they have already been fully described and illustrated in a paper by E. W. Bolle-Jones published in 1956 (*J. Rubb. Res. Inst. Malaya*, **14**, 493-584).

In acknowledging his debt to the pioneers of *Hevea* pathology in Malaya, who were associated with the government agricultural service, the author has surprisingly omitted the name of W. N. C. Belgrave. It was Belgrave who first studied and determined the cause of red root-disease and who contributed largely to a proper understanding of the two must important diseases of the tapping-panel, mouldy-rot and black-stripe. It would have been more appropriate, too, had the name of Arnold Sharples been mentioned as one of the pioneers rather than merely as a former officer of the Pathological Division of the Rubber Research Institute. Before joining the Rubber Research Institute (in which he served for three years), Sharples had already spent some 15 years investigating all aspects of disease in rubber as a government mycologist, and it was during this period that most of his papers on the subject were published. R. A. Altson.

Rice (3rd Edition). D. H. Grist. Longmans, London. 48s.

The third edition of *Rice* will be welcomed not only for its three new chapters, two on genetics and breeding and one on weeds, but also for the general revision and expansion which brings up to date a textbook already established with all who deal with rice as a crop or commodity.

The new chapters are valuable additions to a book whose accent is on improving the nutrition obtained from rice, both by increasing production and by improving the quality of the crop. Although of a long-term nature, plant breeding is a method by which both these ends may be furthered, and since it is carried out at someone else's expense it is a method which the farmer can always afford. Besides producing varieties of greater yield and nutrition, breeding also plays an important rôle in pest and disease control, and offers probably the only hope for the control of many virus diseases, for example, the virulent *Hoja blanca* which is decimating crops in South America and which, incidentally, obtains but the briefest reference in *Rice*.

Chemical weed control in rice, as yet in the experimental stages, is fully discussed in the new chapter which reaches the conclusion that 'hand weeding remains the most efficient means of weed control'. On the other hand, pest control is well advanced and this much enlarged section now forms quite a useful reference to the control of most important species with modern insecticides. An important omission from this section, considering the number of fatalities due to the use of organo-

phosphorus insecticides on rice, is a note about the safe handling of insecticides.

The revised volume is conveniently divided into three sections: *Oryza sativa* L.: The Plant; Paddy: Production; and Rice: The Product. There are several useful appendices, including two on fish cultivation in paddy fields and the risk to them of pesticides. A good index and over 550 references complete this excellent and up-to-date edition. J. B. WINFIELD.

Farm Organization and Management. GORDON HAYES. Crosby Lockwood, London. 25s.

This book is divided into four parts: the general agricultural background; economic considerations; organisation of different enterprises; and farm planning. In the six clearly and concisely written chapters of Part I, the author discusses land use; land use control; the agricultural worker; agricultural marketing; and agricultural prices, in terms suitable for the agricultural student at Diploma level and for the general reader.

In Part II, the subjects discussed are: economic considerations; land tenure; labour utilisation; mechanisation; and farming capital. There is in these chapters a wealth of useful information for the student and general reader but the author is perhaps too inclined to base his discussions upon statistical data, culled from diverse sources, instead of using these data to illustrate and illuminate the general discussion. In a lengthy section on diminishing returns, most of the figures quoted refer to milk production but no reference is made to the fact that the good farmer is always striving to counteract the effect of diminishing returns by improvements in some of the other factors involved, such as the milk yield per cow. Hence, although it may be uneconomic to feed 30cwt. of cake to a cow capable of a lactation yield of only 700gal., it may be highly profitable to feed 35cwt. to a cow with a potential yield of 1,200gal.

There is no doubt that the statistical tables on labour utilisation, mechanisation and capital requirements do provide extremely useful information but since they are based upon average results from groups of farms their value to the individual farmer is strictly limited, because his particular farm may differ quite widely in several respects from the average farm of the group. This weakness of average results in relation to a particular farm might have been stressed more than it has been.

Part III of the book discusses in turn what is rather misleadingly called the 'organisation' for the production of crops, milk, beef, sheep, pigs and poultry. As in Part II, much of the discussion is based upon statistical tables, some of which are not very well chosen. There seems little point in giving what purport to be average production costs per acre of crops and per gallon of milk for the whole of England and Wales and of Scotland. It is well known that there are very wide variations in the results on individual farms and the practical farmer is far more interested in the reasons for these variations than in the average results. Even so, why should the production cost per gallon of milk average 2s. 5½d. in England and Wales and only 2s. in Scotland? No explanation is offered.

There are some serious omissions from the discussion. For example, no attempt is made to illustrate the relative importance, in the determination of profit, of cost per acre and yield per acre or of cost per cow and yield per cow in milk production; in the chapter on milk production nothing is said about the disease factor in economic production, although much is written about the feeding of cows, which lies in the sphere of animal husbandry rather than of organisation; and, perhaps most surprising of all in a book of this kind, the distinction between overhead or fixed and variable costs is passed over very lightly.

Despite these criticisms, this section of the book contains much information of great interest and value, especially to the student and general reader, and the author shows a wide knowledge of practical farming problems.

The first chapter in Part IV deals on fairly conventional lines with the measurement of farming efficiency but two points have not been stressed as much as they might have been. First, the use of efficiency standards presuppose accurate and systematic recording of the basic facts, both financial and physical; secondly, it seldom happens that a particular farm in a group of farms will occupy the same order of merit when tested by several efficiency standards; that is, improved organisation cannot be based entirely upon such standards but must remain partly, even largely, a matter of the farmer's judgment.

The last two chapters, on farm planning—more often called budgeting—make rather stiff reading. An example is given in great detail of a farm which is organised according to four 'management alternatives'. Certainly this kind of example is great fun for the agricultural student who must, perforce, do his farming on paper. But one cannot help wondering just how many of the thousands of farmers who now own a combine harvester first made a partial budget on the lines here laid down. While the economist figures, the farmer decides! JAMES WYLLIE.

Farm Business Management. D. G. PEARCE. Oliver & Boyd, Edinburgh and London. 15s.

There is now general agreement amongst farming advisers, as well as amongst a growing number of farmers, that well-designed and properly used accounts can give the farmer material assistance in his search for greater productive efficiency. The author of this book is an enthusiastic supporter of that idea. He deals with what he calls 'business efficiency' in farming under three main heads: Accounting, Budgeting, and Controlling.

Many of his ideas, and much of his terminology, have at least the merit of originality but this is not to say that they are invariably either sound or practicable. Contrary to most other workers in the same field, the foundation of his scheme is a complete farm budget, rather than a properly constructed set of accounts. Budgeting is described as 'the pivot of the farm business' and the chief purpose of the accounting system would appear to be to ensure that the budget is fully realised. Thus, 'the whole object of comparing this relationship [between inputs and outputs] is that as the year progresses the farmer can make any adjustments which he may think necessary to assure the achievement of the budget'.

In the author's view, budgeting has become a science, and by making use of the efficiency standards devised by university departments of agriculture economics planning has become 'almost a mathematical exercise'. Nevertheless, the first step in preparing a budget for any farm must be to make a careful assessment of the farmer's managerial capacity and of the productive capacity of his land and livestock, and it is admitted that this remains largely a matter of judgement. However, the accounts are not to be completely ignored in making a budget and here the novel suggestion is made that a 'predicted' profit and loss account and a 'predicted' balance sheet should be prepared 'about two-thirds the way through the year, or after the peak period of seasonal production', so that the budget for the next farming year may be completed in good time. Finally, it is asserted that failure to answer correctly many of

the problems in farming is due to 'a haphazard approach to budgeting'.

Despite the assurance with which the author puts forward the case for budgeting, many, perhaps most, readers will find it far from convincing. It is indeed remarkable that, although he has had many years' practical experience as a farmer on a large scale, he has made no attempt to illustrate and illumine his argument from that experience. Such a demonstration of the possibility of effective application of the author's ideas would have been invaluable, because the chief criticism of a complete farm budget is that it generally differs so widely from the realised results.

It is surprising that no reference is made to the partial budget which is now widely used by farm management advisers, and one is left wondering whether this omission was inadvertent or because the partial budget was not thought to be worthy of mention.

One of the chief features of the section on accounting is the emphasis given to the balance sheet. In current investigations, the balance sheet receives rather perfunctory attention, or none at all, and yet the capital situation on a farm, as shown by the balance sheet, may be of vital importance. It is unfortunate that the author shows such marked intolerance towards conventional methods of accounting; witness his gibe about 'the archaic system initiated by Noah when he filled the ark—namely, double entry'. It is a simple fact that the primary and common purpose of any method of accounting is that it must meet the requirements of the Inland Revenue and there is little doubt that the increased use of accounts for management purposes must depend partly on the active co-operation of professional accountants.

The last section, on controlling, is most admirable. In two chapters, covering fully one-third of the book, the author makes a searching analysis of the general principles on which good organisation (of operations and jobs) and good leadership must be based. In particular, the discussion of what constitutes good leadership is much the best which this reviewer has yet come across. It is significant, however, that these two chapters include only a few passing references to either accounting or budgeting. It is clearly the view of the author, as indeed of successful farmers everywhere, that not even the most perfect methods of budgeting and accounting will fully compensate for deficiencies in labour management—here called organisation and leadership. JAMES WYLLIE.

Farm Mechanization Management. C. CULPIN. Crosby Lockwood, London. 21s.

Since 1939, when the mechanisation of British farms began in earnest, the farmer's approach to his mechanical equipment has changed in emphasis. Originally 'mechanisation' meant simply the introduction of machinery to the farm, and the most important questions were usually 'How does it work?' and 'How do I keep it working?' Now, 20 years and almost a new generation of farmers later, knowledge of at least elementary mechanical principles is commonplace, and reliability is often taken for granted. These factors, together with an economic environment that places a premium on the efficient use of resources, lead nowadays most often to the questions 'Is it economically justifiable on my farm?' and 'How do I organise the system of working?'.

Much of Mr. Culpin's new book is devoted to answering these two questions. This volume supersedes his book, *Farm Mechanization—Costs and Methods*, published some eight years ago, and the new title underlines the change in emphasis. Instead of being a subject out on its own, farm mechanisation —in its widest sense—must now be recognised as a vital factor to be integrated with the overall management of a farm.

Thus Mr. Culpin is concerned in the opening chapter with the history of the development of mechanisation on a national scale, and in discussing the general factors influencing the cost of using machines. The factors which affect individual farmers and determine the actual cost of using machines in particular circumstances are very clearly reviewed in the following chapter. The book then goes on to study managerial aspects of the subject, such as standards for checking the efficiency of mechanisation, and the use of partial budgeting and other methods of making a choice of equipment on economic grounds. The contribution to be expected from the application of work study techniques is also discussed in detail.

The various factors affecting particular sections of farm mechanical equipment are considered in the main part of the book. Starting with tractors and farm power, this continues through machinery for crop production and for harvesting green fodder, corn and root crops. The final chapter is devoted to a comprehensive discussion of the equipment used in connection with livestock tending. Wherever possible, published data relating to performance is quoted, and the best methods of organising the use of machines and equipment are described.

The volume is completed by an index, a very extensive bibliography and an appendix of 12 tables of data regarding such things as effective capacities of field machinery, estimated length of life of equipment, cost of repairs, relevant standards, etc., all of which are important in making the various managerial decisions discussed earlier in the book.

No one volume, however comprehensive, can answer directly all the questions an individual farmer may ask. *Farm Mechanization Management* nevertheless contrives to bring together a very great deal of published information, and to present it in such a way that any farmer can compare his own methods and achievements with the standards quoted. It is a book which will be of the utmost value to the student of farm management or farm mechanisation. It has an even greater value than this, however, in providing a challenge to the thinking farmer, to stand back and examine his management of machinery. In the light of a critical examination of this kind, unsuspected weaknesses of selection or organisation are bound to be detected. The result can only be to improve the farmer's production efficiency and to benefit his pocket. J. A. C. GIBB.

Forest Machinery. E. R. HUGGARD and T. H. OWEN. A. & C. Black, London. 24s.

This well-produced and authoritative volume describes the very wide range of plant and machinery used within the modern forest. It is particularly well illustrated by photographs and drawings and, mainly in tabular form, contains much information regarding the specifications and operating capacities of the machines mentioned.

The main part of the book is concerned with nursery equipment, machinery for land preparation and forest establishment, felling, rough conversion and extraction. The range of available machines of each kind is discussed, and their suitability for specific conditions is indicated. Practical operational points are also mentioned in many cases. Other chapters deal with road construction, fire-fighting and forest pest control equipment.

The managerial aspects of forest mechanisation are discussed

in the early part of the book, and the importance of planned machine selection and management is stressed. A valuable chapter deals with the economic considerations, and introduces a standardised scheme for the costing of vehicles and machines. Although the point is made that, in the past, costing schemes have often been neglected by foresters on the grounds of complication and intricacy, the suggested method—prepared by a joint study group working under the auspices of the Food and Agriculture Organisation/Economic Commission for Europe—strikes the reader as no exception to this rule.

Once the scheme is understood, however, it is indeed a sound and comparatively straightforward method of evaluating and comparing the costs of using different types of machinery. It is therefore unfortunate that the method of presentation is not as clear as is desirable, and a departure from the detailed layout of the FAO/ECE scheme might well have been advantageous.

The volume includes a short but useful index, a list of acknowledgements which, in conjunction with the illustration credits, also forms a directory of equipment manufacturers, and a number of appendices giving relevant data such as the safe loads for wire ropes, effect of gradients on tractor pulling power, etc.

In all, the authors are to be congratulated on producing a volume which remains very readable in spite of its highly factual and tabular nature. It should be of very considerable value to all concerned with mechanised forestry operations, from either a practical or a managerial standpoint. J. A. C. Gibb.

Parasitic Animals (second edition). G. Lapage. Heffer, Cambridge. 25s.

For over 20 years we have been enlightened and entertained by the books on parasitology by Dr. Geoffrey Lapage. The remarkable creatures which form the subject of his books are only matched by their extraordinary life histories. We have the South American warble fly, *Dermatobia hominis*, loading its eggs on to a blood-sucking fly or mosquito for transport to a mammalian host, or the liver fluke, *Paragonimus westermanni*, which uses a snail and a crayfish to find its mammalian final host. There are the maggots of the warble fly (*Hypoderma sp.*) which penetrate the skin of the legs of cattle, and emerge from the animal's back some 10 months later. There is the female roundworm of the intestine of man and the pig, which can lay 200,000 eggs a day, and may achieve an annual total of 60 million. Yet another sinister parasite, usually overlooked in books on this subject, is the vampire bat, *Desmodus spp.*, which has now been incriminated as transmitting rabies.

The book, *Parasitic Animals*, is designed to present parasitism in all its forms, with glimpses of those that practise this way of life. Dr. Lapage introduces his readers to a number of strange characters with fascinating, if disgusting, habits. One feels that the author, who is indeed one of our most eminent parasitologists, is anxious for us to share his enthusiasm in his subject, and marvel with him at the startling kaleidoscope of life cycles which are presented. The fact that the host to these revels may suffer discomfort, disease, and death, is treated lightly as an unfortunate incident in the fight for survival.

The second edition of this book follows the same format as its predecessor, published eight years ago. The first part is devoted to descriptions of the parasites, their life histories, and their methods of obtaining food. The second half is concerned with the reaction of the host to the diverse forms of attack to which he is subjected. This host-parasite relationship is a vital factor in the co-existence of the two forms of life, because it is obviously not in the interests of the parasite to kill the host who provides it with food and shelter. Unfortunately, the herding of animals, both human and otherwise, upsets the host-parasite relationship very much to the detriment of the host animal. For this reason parasitology is, and is likely to remain, of considerable economic importance.

The parasites are grouped by their respective life histories, their feeding habits, their morphology and their effects on the host. The parasites of such diverse hosts as man, beetles, frogs, horses, sheep, whales, bats and fish are linked by this means. It is always the parasite that takes precedence.

Parasitic Animals is a book to be read from cover to cover. It is not a reference book. It provides a broad and balanced review of the subject of parasitology for doctors, veterinary surgeons, and biologists who practise economic entomology. The 334 pages are easy to read and carry an immense amount of information provided by a man who has devoted his life to the study of his subject. This book gives a panorama of a fascinating branch of science, which, until recently, was much neglected by research workers. D. W. Jolly.

Diseases and Pests on Horticultural Planting Material: a guide to their recognition (second edition). Ministry of Agriculture, Fisheries and Food. H.M. Stationery Office, London. 7s. 6d.

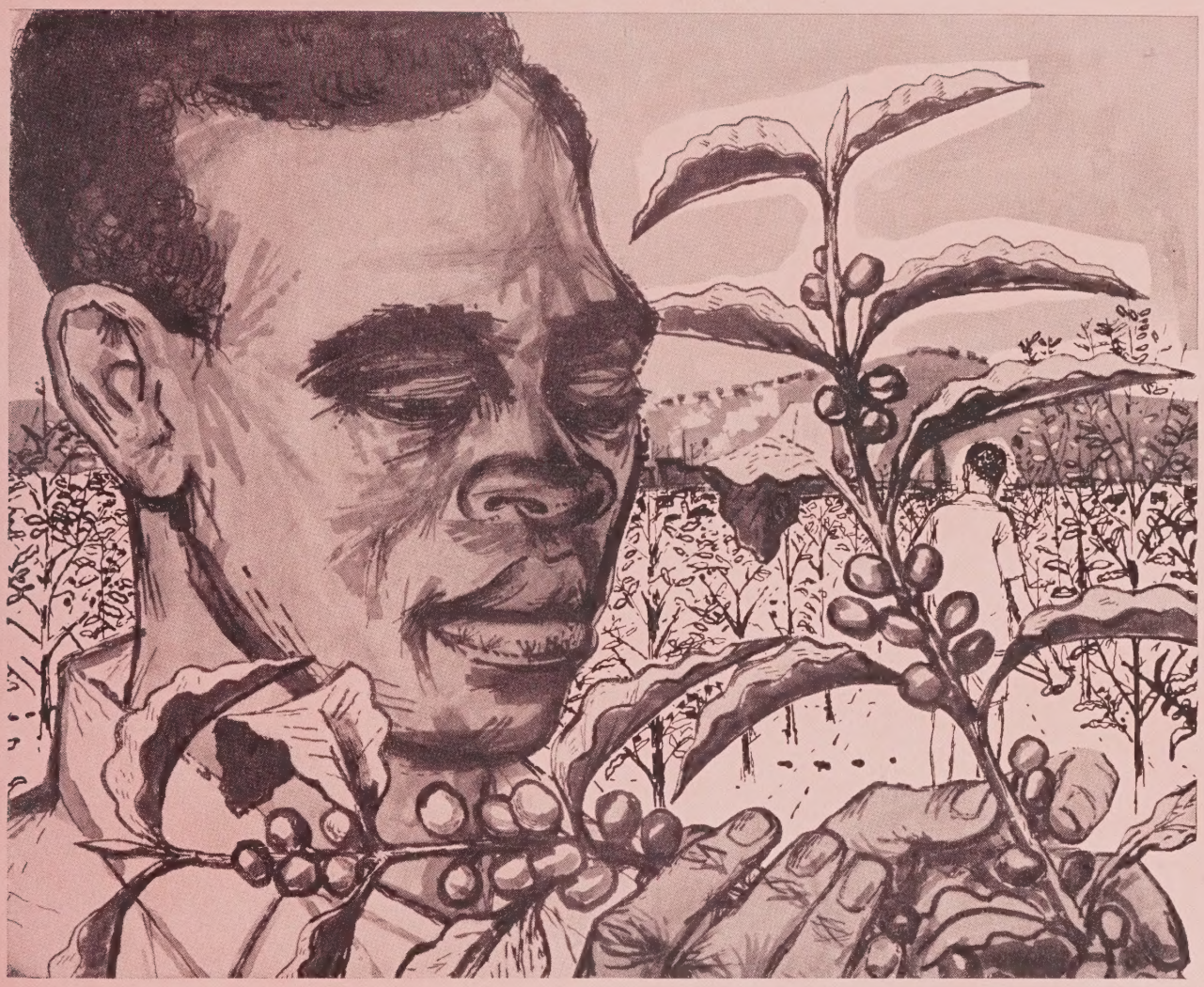
This handbook was first published in 1953, at the suggestion of Mr. F. Glover, formerly the chief horticultural inspector in the Ministry of Agriculture, Fisheries and Food. While members of the Inspectorate are familiar with the pests and diseases found on growing crops, many of these crop disorders are much more difficult to recognise if they are present in dormant or semi-dormant planting material, which is subject to inspection immediately before export from, or on entry into, the country. In modern trade there is considerable movement in horticultural planting material, and this guide covers most of the plants that are grown in temperate and semi-tropical regions of the world.

Under the FAO Plant Protection Convention of 1951 each contracting government undertakes to make provisions for an official plant protection organisation, one of whose duties is the inspection of growing plants, and of consignments of plants moving internationally. This handbook facilitates the work of inspection for the UK-based Inspectorate, and those engaged in plant inspection work in other parts of the world will find it a most useful reference medium. Over 118 species of both hard- and soft-wooded plants are listed, and to help in the identification of pest and disease symptoms there are 83 black and white photographs.

With the ever-increasing importance of virus diseases it is surprising to find that they are not mentioned; perhaps a specific guide on the subject will be produced. Several eelworms are listed, but no mention is made of the citrus nematode, *Tylenchulus semipenetrans*, which is surprising, since this pest is met with in many parts of the world where citrus is grown.

Raisers of plants in Britain both for export and home sales would be well advised to obtain the guide and use it as a source of reference. Libraries and institutes concerned with horticultural education would find it readily sought after by people who are interested in the study of pests and diseases of plants.

The new editors, Mr. P. Aitkenhead and Mr. J. J. Baker, have sought the advice of many specialists in the compilation of the handbook, and are to be congratulated in producing such a concise and easily read publication. W. R. Caseby.



Coffee line

From Bonabéri, on the wide estuary of the Wouri river, the Chemin de Fer du Nord runs just 160 kilometres to its terminus at N'Kongsamba. A short line, in the immensity of Africa, but a picturesque one. Winding first through evergreen rain forest and the humid zone of oil palm and banana, it then climbs steadily into a land of black volcanic earth where, in March, the air is sweetly scented and every tree a foam of blossom. Here, in the Mungo district of Cameroun, is grown the country's biggest tonnage of *Robusta* coffee. And here, an insect pest struck recently with unexpectedly vicious force.

Normally, damage by the coffee clear wing moth (*Cephonodes hylas* L.), known in most of the coffee-growing areas of Africa, is reasonably easy to control, and hand destruction of the big green and white caterpillars is sufficient. In May 1957 however, very heavy infestations caught the planters by surprise ; hand picking failed to check the pests, and in some plantations trees were quickly stripped of two-thirds of their foliage. An immediate appeal for aid was made to the N'Kolbisson Entomology Laboratory near Yaoundé.

The answer was swift, effective and based on Shell endrin. A formulation of 19.5% endrin applied at a rate of 3 litres per hectare in 500-1000 litres of water was recommended, and results were spectacular. Even the largest caterpillars were rapidly killed, and 100% control was achieved within 12 hours—yet another example of the killing power of this important foliage insecticide developed by Shell. With the aid of endrin the coffee line to Bonabéri carried full loads in 1957 ; with the aid of endrin many other crops come safely to harvest year by year in many parts of the world.

Shell endrin

Cephonodes hylas L.

Endrin is one of six Shell pesticides for world-wide use. Between them, endrin, aldrin, dieldrin, Phosdrin, D-D and Nemagon offer control of virtually every significant pest, both above and below the soil. In addition, dieldrin has important uses in public health. Have you a pest problem in your area? Your Shell Company will gladly advise you on methods of control or eradication.

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